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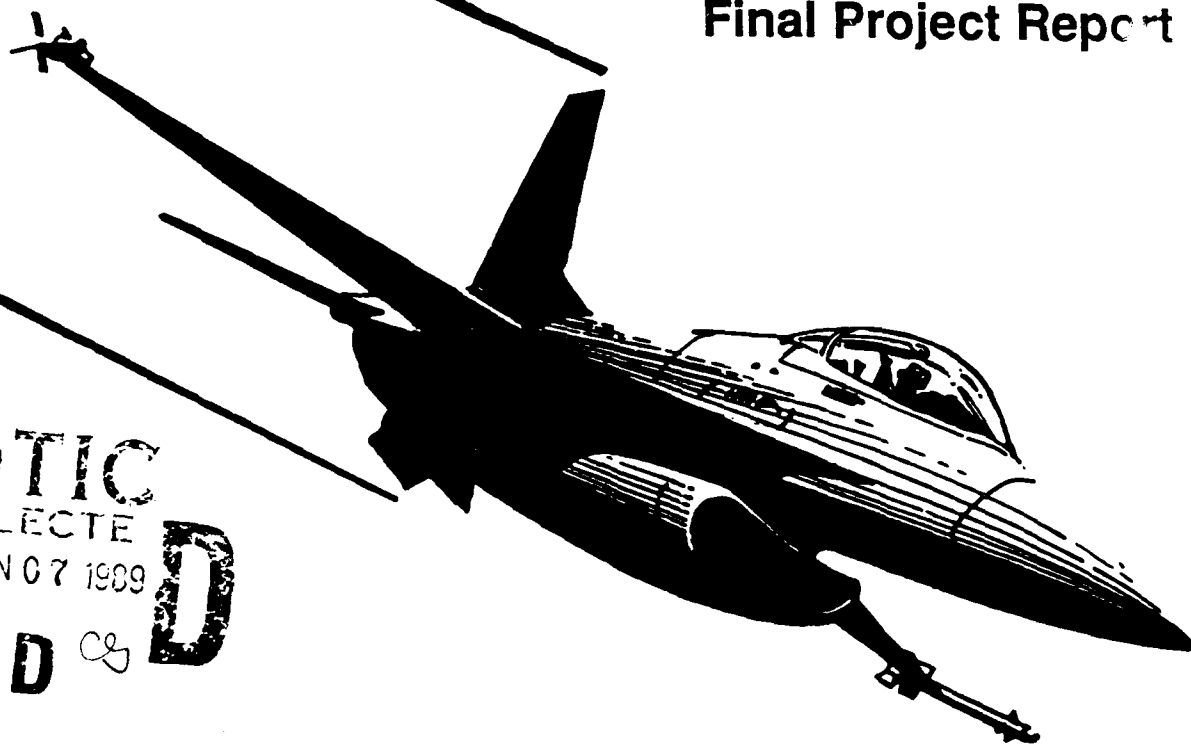### FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

Phase 2
Final Project Report

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PROJECT 28

AUTOMATION OF RECEIVING, RECEIVING INSPECTION AND STORES

Honeywell
Military Avionics Division

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This project encompases the evaluation, justification, and preplanning required to convert the current flight systems operations material handling and inspection function into a modern automated system. There is a focus on dedicated work cells, automated storage and retrieval system, and integrated support equipment. The objectives are to reduce material costs, material scrap, procurement lead-time, and manual material handling and storage. Also anticipated are improvements in labor efficiency and inventory control.

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GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY
MODERNIZATION PROGRAM

Phase 2
Final Project Report

PROJECT 28

AUTOMATION OF RECEIVING, RECEIVING INSPECTION AND STORES

AVIONICS SYSTEMS GROUP
MILITARY AVIONICS DIVISION
1625 ZARTHAN AVE
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PROJECT 28

AUTOMATION OF RECEIVING, RECEIVING INSPECTION AND STORES

SECTION 1

INTRODUCTION

The basic thrust of Project 28 is to integrate the functions of receiving, receiving inspection and central stores into a single computer controlled automated handling and storage system. This includes comprehensive planning, evaluation and justification in order to integrate our current functions into a modern automated facility.

The benefits to be derived from the proposed system are increased labor productivity, improved inventory accuracy, reduced procurement lead time, and reduced inventory carrying costs.

The integrated system will control incoming materials from the receiving dock into storage, from storage into receiving inspection, from inspection back into storage, out of storage to a picking area and then into a consolidation area. All items will be handled by conveyor and stored in carousels, except pallet loads, with a computer tracking system maintaining inventory control and location of parts at all stages of the operation.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The objective of this project is to provide a state-of-the-art, integrated computerized material handling and storage system to move and control production material from receiving, through receiving inspection to stock and from stock ready for delivery to the assembly areas. This has been accomplished by evaluating the functions necessary to achieve this end result and integrating these functions into a smoothly controlled handling and storage system.

The key components of the integrated system include:

RECEIVING

Modular receiving stations will be set up at the head of the conveyor system for receiving, identifying and inputting data to the Honeywell Manufacturing System (HMS) and Business Operating System (BOS) upon receipt of material items, and placing containers with these items onto the conveyor for storage in carousels prior to receiving inspection.

STORAGE AND RETRIEVAL

A computer controlled carousel storage system receiving incoming items by conveyor prior to inspection and dispatching materials to receiving inspection on a priority basis.

RECEIVING INSPECTION

Modular inspection stations adjacent to the receiving inspection transporter will receive trays of items to be inspected from the receiving inspection dispatcher. This person requests items from storage on a priority basis and directs them to the proper inspector.

STOCKROOM

Modular combination stocking and picking stations adjacent to a transporter will feed and retrieve items from a fully automated carousel storage and retrieval system (the same system storing incoming material prior to inspection). This will eliminate a major portion of the manual handling involved in the inshipping and order filling functions in the stockroom.

STOCKROOM ORDER FILLING

Computer generated orders are displayed on CRT's at each pick station in a batch mode. This will reduce scale setup time and tote traffic. The return transporter will deliver tote trays to the consolidation area for kit accumulation.

CONSOLIDATION MATRIX

The computer activated kit accumulation matrix with indicator lights for each kit location will be activated by bar code scanning of item labels.

SECTION 3

TECHNICAL APPROACH

The technical approach to Phase 2 of this project started with the establishment of a project team to prepare the Phase 2 proposal. The team was composed of representatives of the following departments: Receiving, Receiving Inspection, Stores, Material Handling Engineering, Industrial Engineering, Central Production Control, Procurement and the Program Office. Preparation of the Phase 2 proposal included an analysis of the existing operations in receiving, receiving inspection and the stockroom to establish As-Is conditions. A preliminary To-Be plan was prepared integrating these functions based on projections of future needs for these services.

Upon completion of the Phase 2 proposal, six months prior to Phase 2 award, a search was conducted to engage a consulting firm capable of designing a handling, storage and control system which would accomplish our objectives. Several system suppliers were requested to bid on the development project, our final decision was to go with an independent consultant, Productivity Systems Inc. (PSI). Our decision was based on PSI's experience in designing and managing the installation of systems similar to ours and their independence from any one manufacturer.

The Honeywell project team, together with PSI, took the following approach to develop an integrated material handling and storage system, complete with all of the necessary controls, to operate under the Honeywell Manufacturing System (HMS).

DETERMINE DESIGN REQUIREMENTS

An exhaustive and detailed investigation and analysis was made of all current activities in the effected operations. Current material storage, handling and control requirements were established as a basis for our As-Is conditions. The required throughput, storage capacity and necessary interfaces with Procurement, Inventory Control and the Product Sections were projected. This was the basis for establishing our To-Be requirements. The projection considered make versus buy, JIT, business growth and other factors which might change our requirements. This information was analyzed and incorporated into a comprehensive Project Database.

DEVELOP ALTERNATIVE CONFIGURATIONS AND CONCEPTS

A variety of alternative system concepts and configurations as well as the most suitable location in the building were considered in order to meet the requirements of our system. These were developed and reviewed using a "bottom up" approach to ensure that the resulting system design would satisfy the requirements of the functions to be performed.

EVALUATE ALTERNATIVES

Criteria were established to evaluate the alternatives, including availability of standard equipment, appropriate levels of automation, productivity improvement potential and return on investment.

SELECT OPTIMUM SYSTEM CONFIGURATION

A final system concept was selected by the team for further development. This was based on the system that would be the most effective in interfacing with the Honeywell Manufacturing System, the Business Operating System and integrating Receiving, Receiving Inspection and Stores functions.

DEVELOP A FINAL DESIGN AND DRAFT THE SPECIFICATIONS

A formal specification was then developed to completely describe and define the complete system design and operation. System layout drawings were developed for the areas chosen for the installation and a computer simulation was run on the system to verify its capabilities.

SELECT COMPETENT SYSTEM SUPPLIERS

System suppliers were selected based on a survey of the industry to determine which companies had the capability and experience to complete this project. Seven companies were selected and contacted to discuss their interest in quoting on the project. They were then provided with a complete bid package.

REVIEW AND EVALUATE VENDOR RESPONSES

Five responses were received and evaluated using a vendor evaluation criteria matrix. Two bids were set aside as not sufficiently responsive to the specification and a third because of a lack of sufficient detail to evaluate the proposed equipment configuration and system operation.

SELECT VENDOR

Two vendors submitted complete bid packages and responded to written requests to clarify some areas of their proposal. They were then both invited to make presentations to the project team. This resulted in further questions and responses. A final evaluation of the bid responses was made by the team and a vendor was selected.

FINALIZE DESIGN AND SPECIFICATIONS

Based on the chosen vendors proposal, the final layout drawings and specifications were prepared and a facilities plan and implementation schedule determined.

PREPARE COST BENEFIT ANALYSIS

Based on the final bid package and facilities estimate, a final Cost Benefit Analysis was made and a financial analysis prepared showing cash flow, expenses, ROI, etc. In addition, a cost tracking system was designed to monitor actual costs and savings after implementation.

SECTION 4

"AS-IS" PROCESS

INTRODUCTION

The present system is a completely manual handling and storage system with containers of parts moved on shelf trucks or table top trucks between operations and stored on shelving in the stock areas.

RECEIVING

Parts are received by Dock personnel. Dock personnel use packing slips received with the parts to generate a Move Order and Inship for parts. Those parts which cannot be inshipped (due to no purchase order on file, etc.) are put on a problem shelf in the Receiving area. These problems are resolved using manual methods. After counting, the Move Order is attached to the container of parts. The parts which require inspection are placed on a shelf truck and moved into the Receiving Inspection area by a Stores Material Handler and the Packing Slip and Inship are brought into Receiving Inspection. Those parts not requiring inspection are delivered by hand truck to the requesting area or to the Stockroom inship area.

RECEIVING INSPECTION

Using the Inship generated above, the Receiving Inspection Clerk generates an I.D.I. (Inspection Data Input) Sheet. At this point, the I.P. (Inspection Procedure) folder is removed from the files by a Receiving Inspection Clerk and combined with the paperwork and parts. The complete package/packages are now moved on a shelf truck to the bar-code area. After bar-coding is completed the entire package of parts and paperwork is moved on a shelf truck to the Inspection work center, where it is removed from the truck and placed on a section of shelving. Material which is in queue (waiting to be inspected) is stored on shelving at the work center. Parts are removed from the shelving and inspected on a first-in, first-out basis unless a priority for a particular part is established. Priorities are established on a manual basis by manual tracking of material.

At the Inspection work station some items need to be "Farmed-Out" to other Inspection areas in Honeywell. The parts are then logged in and the paperwork filed in the "Farm-Out" file. These "Farm-Outs" are loaded on a shelf truck and moved to another part of the building or moved to the dock and loaded into a trailer to be delivered to another building for inspection. When a "Farm-Out" sample is being sent out (versus the entire lot), the balance of the lot is stored at the work station on shelving until "Farm-Out" results are returned to that work station.

When a particular lot of parts has been inspected and is accepted the following actions occur:

• The original I.D.I. is brought to the Keypunch Operator.

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- One copy of the I.D.I. is given to the Receiving Inspection Factory Clerk who places it in a file in the Receiving Inspection area.

- The Move Order is attached to the container of parts and stamped "Accepted". Parts are hand carried to the Stockroom Inship Area and placed on a shelf.

In the event the parts are rejected the following events occur:

- Parts are placed on a table top truck and delivered to the Bond Room where the Bond Room Attendant logs in the parts and places them on a shelf until disposition of the parts occurs.

- A copy of the I.D.I. with the Move Order is sent to the Bond Room along with the parts.

- At the time of disposition, change notices are generated for part distribution and parts are placed on a shelf truck and either sent to stock, returned to the vendor or scrapped.

STOCKROOM

After the parts have been hand carried or trucked to the Stockroom Inship Area, the parts are hand counted and bagged in antistatic bags. The parts are placed in containers, the containers placed on table top trucks and moved into the Stockroom were they are randomly located in shelving by Stores Material Handling personnel. After location of the parts, a Stores Clerk uses a terminal located in the Stockroom to input the location, lot number and quantity of parts received into the Inventory Control System (currently GAPOS).

Piece parts and/or assemblies are currently withdrawn from the stockroom for the following reasons:

1. Shipment to a customer.

2. Transfer of parts to someone not using the Inventory System.

3. Transfer of parts to a different "Control Area" on the Inventory System.

4. Immediate need of parts for the Production area (Hot Line Tickets hand carried to the Stockroom).

5. Surplus and segregation of parts.

6. Pulling of parts for Manufacturing Subassembly (MSA) Job Orders (FAB FAC).

7. Stock Withdrawal Tickets which are automatically generated for Kits that have been released the previous day.

Upon receipt of the Stock Withdrawal Ticket for reasons 1 through 6 above, the Stores Clerk looks up the appropriate location on a computer terminal and enters it on the Stock Withdrawal form. This step is not required for reason 7, listed above. After the location has been entered on the ticket, the Stores Material Handling person goes to the appropriate location and removes the

tray of parts from the shelving. If weigh counting of parts is required, the Stores person walks to a scale in the Stockroom, counts and bags the parts, and returns the container to its location on the shelving. The Stock Withdrawal Ticket is then attached to the package of parts and the parts are sent to the proper Production area. When filling parts for a Kit Issue (reason 7, above), parts are not sent to the Production area until the complete Kit of parts has been filled. The Stock Withdrawal Tickets for these parts are sorted in location sequence to reduce the amount of walking required by the Stores person when filling a kit. Refer to Figure 4.1 for an overview of the As-Is process, and Figure 4.2 for the As-Is layout of the area.

FACILITIES

The St. Louis Park Honeywell facility has been occupied in part by the Avionics Division since 1973. The Avionics Division, as it has grown, has gradually increased the area it occupies in this building. It now occupies nearly the entire building. The square footage of the building was increased by expanding the 2nd floor over the entire building.

The functional areas covered by this project have remained in essentially the same location since 1973. During the last 14 years improvements have been made in the material flow in Receiving and Receiving Inspection. In 1984, the Stockroom was relocated and the flow improved. See Figure 4.2 for the "As-Is" facility layout.

WORK FORCE AS-IS

YEAR	MANPOWER
1987	61
1988	63
1989	68
1990	61
1991	57
1992	50
1993	52
1994	54
1995	56
1996	58
1997	60
1998	63
1999	65

EQUIPMENT

1. The departments covered by this project do not have any manufacturing equipment. Aside from the test equipment in Receiving Inspection, the only equipment used in these areas is metal shelving, inspection benches, shelf trucks, and counting scales and an auto-bagger for counting and bagging parts.

2. The computer system is Honeywell's GAPOS which provides information and control of purchase orders, inventory balances, requirements, quality control, etc.
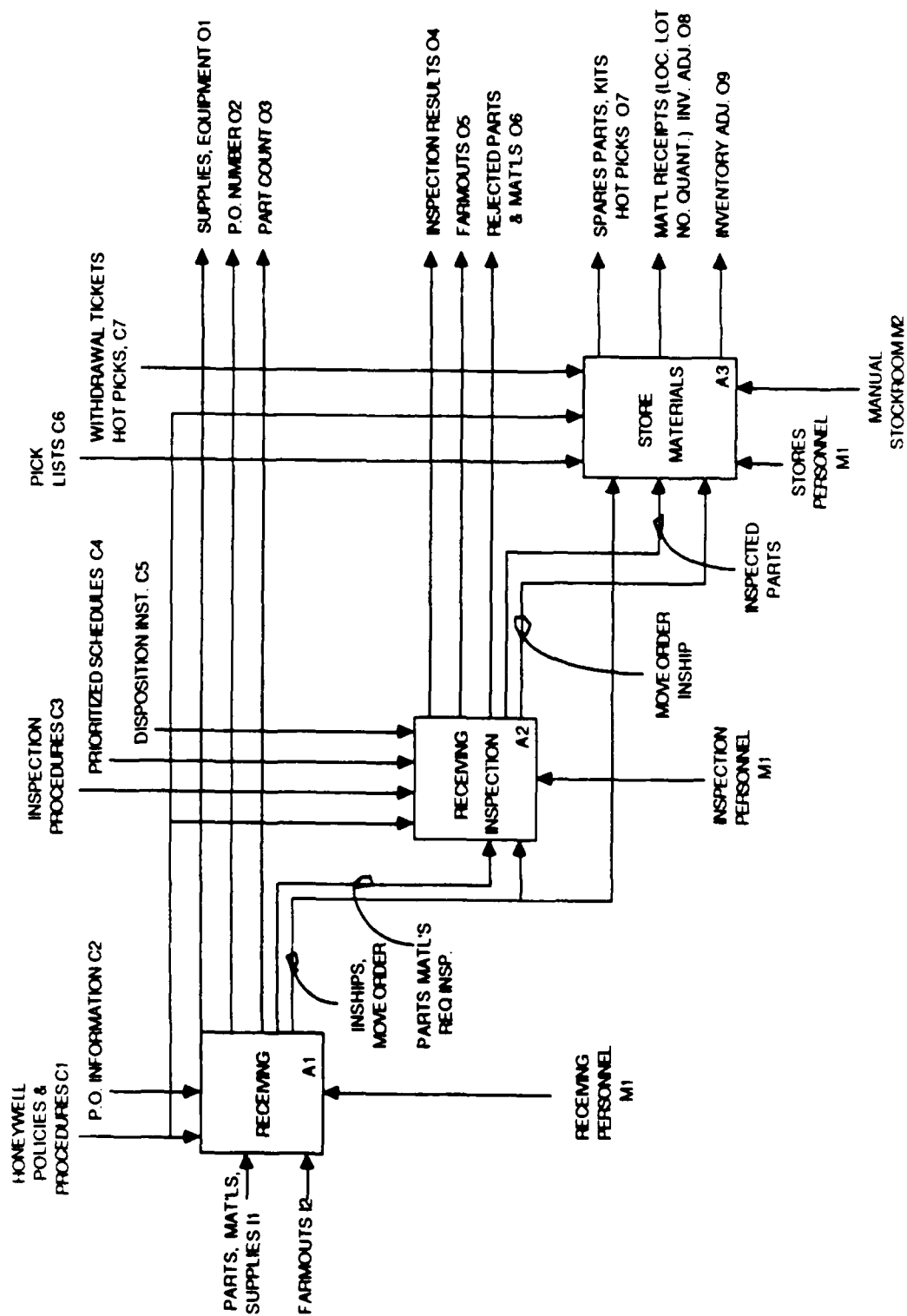
Figure 4.1 As-Is Process
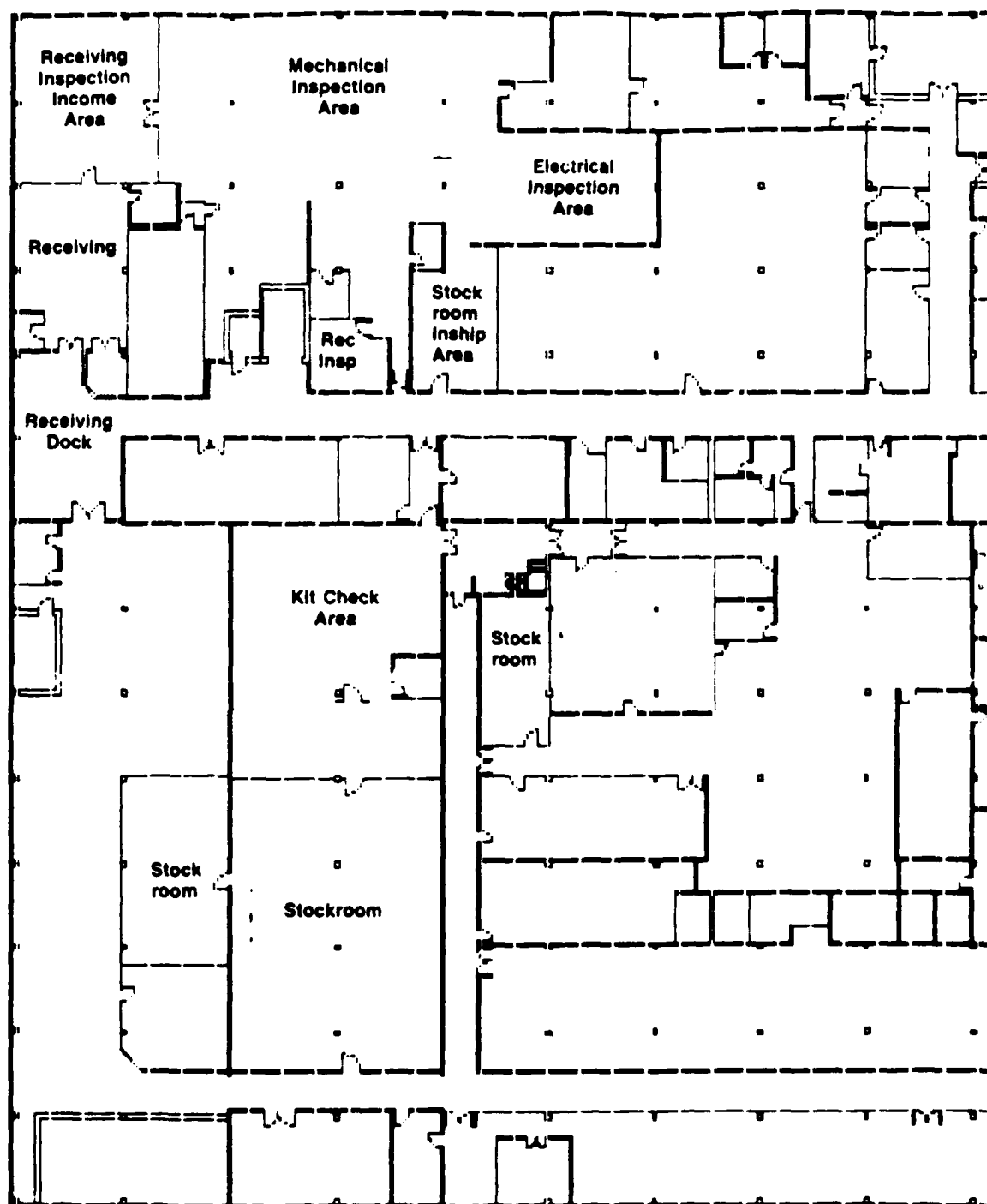
Figure 4.2 As-Is Floor Layout

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DISADVANTAGES OF CURRENT METHOD

The principal cost drivers in the Receiving, Receiving Inspection and Stores areas are manual handling and transporting. This includes:

1. Receiving, where the parts must be sorted and loaded either on a table top truck and delivered to the requesting areas or onto a shelf truck and moved into the Receiving Inspection incoming area.

2. Receiving Inspection incoming area, where the parts must be sorted and reloaded onto another shelf truck and moved into Inspection.

3. Inspection, where the factory clerk must pull the inspection procedure from the file and place it with the parts.

4. Inspection, where the parts must be stored on shelving.

5. Inspection, where the inspector must get the parts from the shelving and move them to the inspection bench.

6. Inspection, where the inspector must move the accepted parts to the stockroom incoming area shelving and the rejected parts to the bond room.

7. The bond room, where the attendant logs in the parts and places them on shelving.

8. The stockroom inship area, where the parts must be removed from the inship area shelving and moved to a bench where they are counted, bagged and placed in a storage container.

9. The stockroom inship area, where the containers of parts are placed on a table top truck and moved into the stockroom.

10. The stockroom, where the containers of parts must be moved on the table top truck into the shelving area and located on a shelf.

11. The stockroom office area, where the stores clerk must input the quantity, lot number and stock location into the inventory control system.

12. The stockroom, where the stores person walks to the shelving location for the parts, removes the tray of parts, moves the tray to the scale, counts and bags the parts and returns the tray to its' location on the shelving.

13. The stockroom, where the stores person trucks the container of parts he has picked into the kit check area.

SECTION 5

"TO-BE" PROCESS

INTRODUCTION

The proposed system will be completely computer controlled with conveyors carrying receipted packages from the dock to the automatic inserter/extractors loading carousels. Containers of parts for inspection will be called out of the carousels by the dispatcher, delivered to his station by conveyor, distributed to inspectors by conveyor, returned to the dispatcher by return conveyor and returned to the carousels from the stocking stations by conveyor. Containers of parts to be picked will be automatically sent to pick stations from the carousels on conveyors and picked parts will be sent to the consolidation area on conveyors.

RECEIVING

Shipments will be received by the Receiving Clerk on the dock who will remove the packing slip and input the Honeywell Purchase Order Number into the computer. The computer will display the items and quantities ordered. This information will be a part of the Honeywell Manufacturing System (HMS) and the Business Operating System (BOS). The items received will be counted and the information entered into the computer which will generate a printed Inship, Move Order and bar-code label. The Inship, Move Order, bar-code and packing slip will be attached to the container. The parts which do not require inspection will be sent to the requesting area. Parts requiring inspection will be stored in the Material Handling System's (MHS) Automatic Storage/Retrieval System (AS/RS). Parts will be identified in the HMS/BOS computerized system by part number, inship number, work center and a "To Stock Date" requirement.

RECEIVING INSPECTION

The Quality Control Code as specified on the Inship will dictate the Inspection Instructions, the Certification Requirements and Government Source Inspection Instructions. For each Receiving Inspection work center, a computer listing will have all Inships in "To Stock Date" order. This will enable the Inspection Dispatcher to concentrate on all priority items on a daily basis. All parts awaiting inspection will physically remain in the AS/RS until inspection is ready to inspect those particular parts. Parts requiring inspection will be entered into the MHS by the Dispatcher on a priority basis. The MHS routes the totes containing these parts to the Inspection Dispatch station. The parts to be inspected are removed from the tote, the Inspection Procedure Information (IPI) folder is removed from a vertical carousel, the bar-code label is wanded which automatically generates a copy of the Inspection Data Input (IDI). The parts, IDI and IPI are placed in a tote and then routed to the appropriate inspection station.

At the Inspection station, it is sometimes necessary to "Farm-Out" (i.e. Electronic Test Center) items for a portion of the inspection. At this point the Inspector will send the samples out. The balance of the lot will be returned to the carousels until the "Farm-Out" sample is returned. The system will allow anyone to go to a terminal and determine the location of the "Farm-Out".

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When a particular lot of parts has been inspected and is accepted, the following actions will occur:

- The original IDI will be sent to Data Entry.

- One copy of the IDI will be placed in a file and kept in Receiving Inspection.

- The Move Order (which was generated at the time of receiving) will be stamped off with an acceptance stamp by the Inspector.

- The container of parts, with attached Move Order, will be placed on a flow rack adjacent to the Stockroom Inship area and located in the AS/RS by the Stockroom Attendant.

In the event that the parts are rejected by Inspection the following events will occur:

- The Inspector will send the parts back to the Receiving Inspection Dispatcher (via conveyor).

- The Receiving Inspection Dispatcher will return the rejected parts to the carousel. The material will be identified as "rejected" and accessible only to Receiving Inspection for disposition.

- A copy of the IDI, along with the Move Order, will be stored with the parts in the carousel. A summary of rejected material stored in the carousels will be generated. The contents of this summary will be similar to the present Hold Room Report.

- At the time of disposition, the Receiving Inspection Dispatcher will remove the rejected material from the carousel and perform one of the following functions:

  1. Place parts with a stamped off Move Order in flow racks for stocking.

  2. Return parts to the vendor on a Procurement Shipping Order (PSO) generated by Procurement.

  3. Scrap, sort or rework parts as directed by the Material Action Release (MAR).

- The Receiving Inspector enters a transaction which will update all required modules of the HMS/BOS at the time of disposition.

STOCKROOM

Parts that are accepted with Move Orders attached will be placed on flow racks adjacent to the Inship Stations. To stock these parts in the carousels, the Stock Attendant unpacks, detrashes, counts and bags the parts and the MHS selects the appropriate storage tote and routes it to the stocking station. The MHS prints a bar-code label for the part which the operator attaches to the bag of parts. The stock attendant wands the part label and tote label. He then wands the "task complete" bar-code from a menu and moves the tote to the return conveyor input, where it is

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automatically returned and stored in the MHS carousel. If a back order exists for these parts, the system will generate a fill requirement for the next day in priority sequence.

Piece parts and/or assemblies will be withdrawn from the Stockroom for one of the following reasons.

1. Shipment to a customer as a spare part.

2. Transfer of parts to someone not using the Inventory System.

3. Transfer of parts to a different "Control Area" on the Inventory System.

4. Immediate need of parts for the Production area (Hot Line requests from the line).

5. Pulling parts for Manufacturing Subassembly (MSA) Job Orders (Fab Fac).

6. Stock Withdrawal Requests for Kit Issues.

Daily requirements for Kit Issues (item 6, above) and individual issues will be called up by the Stockroom Supervisor from the Consolidated Pick List (CPL) module of HMS and released for picking in a batch mode. The MHS retrieves the totes and routes them to the picking stations. As the tote arrives at a picking station, the operator wands the I.D. bar-code of the tote and the CRT displays the parts to be picked. The parts are removed and counted using electronic scales, reel counters or by hand then bagged or otherwise packaged per instructions on the CRT and bar-coded with a label generated by MHS. Upon completion of each pick, the operator will place the parts in the consolidation tote and wand in the bar-code identification as well as his own identification. This will complete the transaction. When the sortation tote is filled, it is moved to an outbound conveyor position and routed to the sortation matrix.

· CONSOLIDATION

As totes arrive at the sortation station, the operator wands the bar-code on the parts and the MHS will light up an indicator light at the matrix position assigned to that kit. The operator will place the parts in the kit tote and push the button at the location to indicate the transaction has been completed and to shut off the light. When the order is completed, the light will flash. The operator will then push the tote to the back of the matrix and MHS will print a complete parts list to go with the order. The completed order will be removed from the back of the matrix and placed on a cart to be delivered to the requesting area. Refer to Figures 5.1 for an overview of the "To-Be" process, Figure 5.2 for the "To-Be" floor layout and Figure 5.3 for the MHS layout of the area.

Figure 5.1 To-Be Process

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Figure 5.2 To-Be Floor Layout

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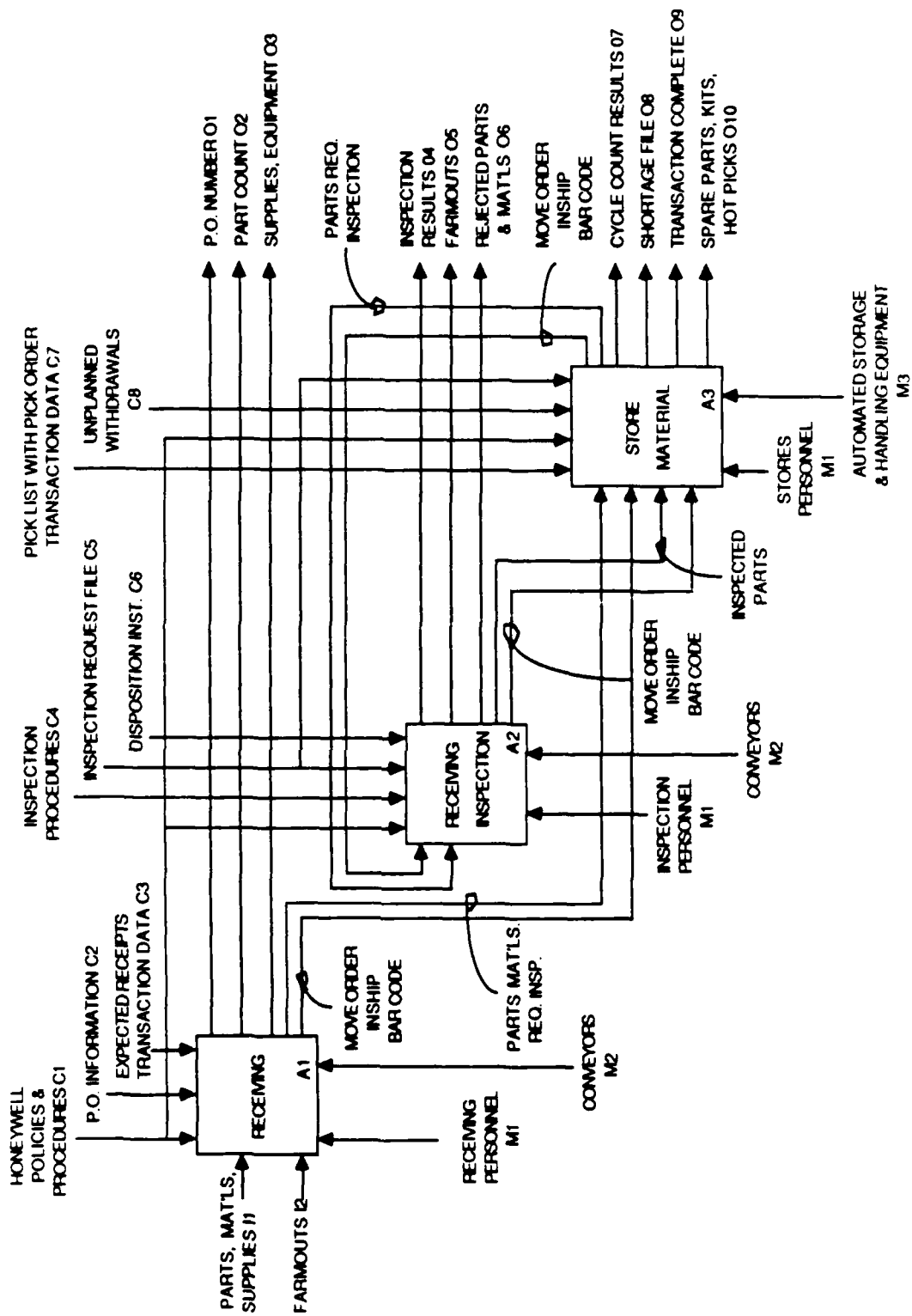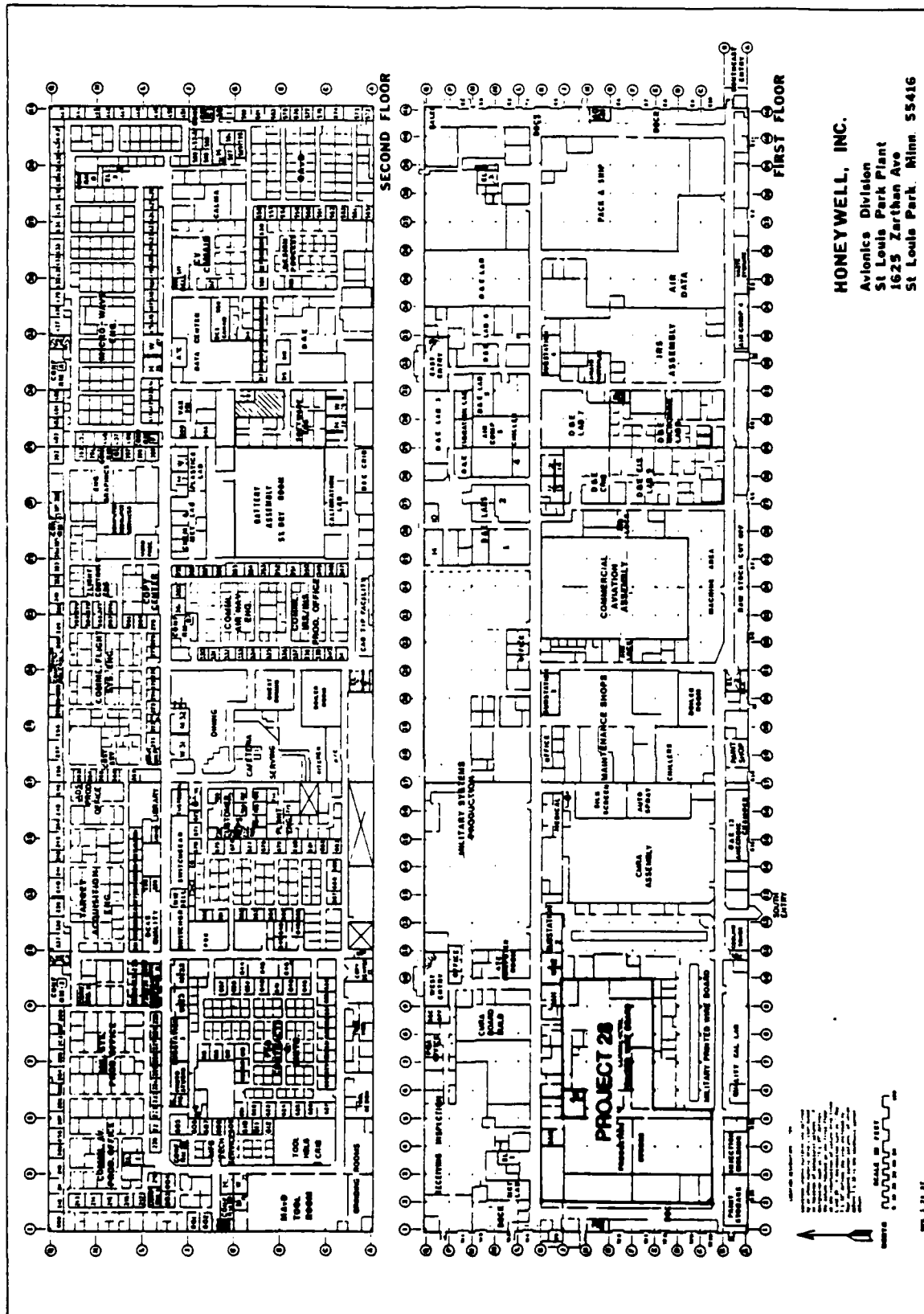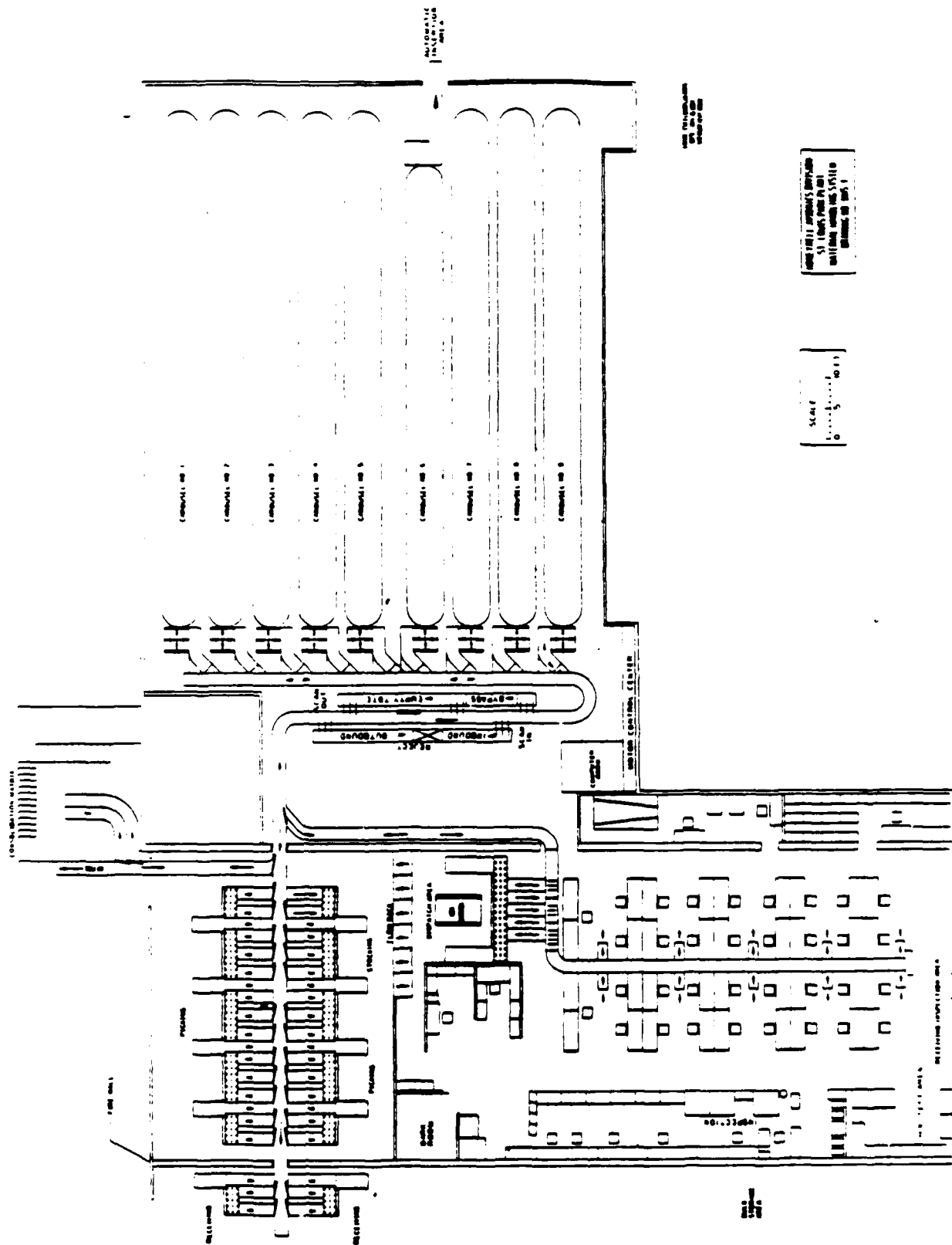
Figure 5.3 MHS Layout

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WORK FORCE TO-BE

YEAR	MANPOWER
1987	61
1988	63
1989	44
1990	40
1991	37
1992	32
1993	34
1994	35
1995	36
1996	38
1997	39
1998	41
1999	42

BENEFITS OF THE PROPOSED SYSTEM

Because of computer control and verification of all transactions as well as all storage and movement activities, significant savings and benefits are anticipated in the following general area:

- Increased work force productivity and reduced personnel requirements (see To-Be versus As-Is workforce comparisons).

- Reduced floor space requirements.

- Improved inventory accuracy.

- Improved picking/stocking accuracy.

- Improved material security and real-time inventory-by-location control.

- Positive control of inspected and un-inspected materials.

- Central handling, control and accountability.

- Improve flow time and cycle time from Receiving through Receiving Inspection and to Stock.

- Improved responsiveness to "Hot Line" requests.

- Improved safety and working conditions.

- Improved parts containerization, ESD protection and parts protection.

- Total integration of all system functions with HMS/BOS control systems.

- Improved reporting and production control planning data support.

SECTION 6

PROJECT ASSUMPTIONS

The assumptions of Project 28 are:

- Dedicated work stations are required. One individual remains in the same location while filling parts orders.

- The system will allow the stock fill rate to go from 18.9 per hour to 47.3 per hour.

- A kit staging area will be incorporated within the stock area.

- The system will allow automatic generation of Hot Line Tickets from the Product areas (via terminals).

- The stockroom will be permitted to combine different lots of parts within one location with parts bagged separately by lot within the location. These locations will be dedicated while like parts are in stock.

- Central stocking of parts will continue for the St. Louis Park facility.

- Assume adequate space is available in the St. Louis Park facility to install the proposed system.

- Assume necessary changes can be made within the local bargaining unit.

- Parts will be located randomly within the storage system due to the need for efficient use of storage space. The storage equipment will be modular, thus allowing for breaking up the Stockroom into various segments based on any changes in business needs.

- St. Louis Park Receiving Inspection will be located in one central location and will remain in the St. Louis Park facility.

- Implementation of this Project will follow the implementation of the Honeywell Manufacturing System (HMS)/Business Operating System (BOS) and the satisfactory operation of the Consolidated Pick List (CPL) in the existing stockrooms.

- Savings data is based on the projected activity increases related to the revenue projections over a 10 year period.

- Capital and expense data are as quoted and have not been negotiated.

- Project 28 is proposed independent of similar ITM Project 20 at Honeywell's Stinson/Ridgway facility. Economies of scale in both capital and expense dollars can occur if both Projects are negotiated and implemented at the same time.

SECTION 7

PRELIMINARY/FINAL DESIGN AND FINDINGS

The approach to the development of the final design has been described in the Technical Approach (Section 3) of this document. At the beginning of this project, the following objectives were established in order to accomplish the general objective of converting the Receiving, Receiving Inspection and Stockroom operations at the St. Louis Park plant into a modern automated facility.

OBJECTIVES

- Consolidate the stockroom into a single area.

- Maximize the storage space utilization.

- Automate all material movement and tracking.

- Provide real-time visibility for part location and movement.

- Centralize handling, control and accountability.

- Integrate record keeping, material movement and transactions.

- Provide physical and data security for segregated stock.

- Prepare operations for upward integration into Honeywell Manufacturing System (HMS)/Business Operating System (BOS) through Consolidated Pick List (CPL).

- Achieve:

  - - Increased Space Utilization

  - - Increased Inventory Accuracy

  - - Increased Material Visibility

  - - Increased Configuration Flexibility

  - - Reduced Labor Cost

  - - Reduced Errors in Handling

  - - Reduced Material Cycle Time

ANALYSIS

An exhaustive and detailed investigation and analysis was made of all current activities in the effected operations and a flow chart prepared to describe these activities (Figure 7.1). Then a cubic volume analysis was made for all of the stock areas considered for inclusion in the proposed storage system (Figure 7.2). Next a study was made of the daily activity in each of the stock areas (Figure 7.3).

From this information a current material handling database was established and a ranking was made of the storage areas that should be included in the consolidated stockroom. The ranking was as follows:

1. Main Stores - Military

2. C room stock

3. Reeled components

4. Main Stores Commercial (eliminated; Commercial Division moving out of the building).

5. IRS crib

6. Receiving/Receiving Inspection

7. W4 Surplus - offsite

8. W7 Termination - offsite

9. W5 Surplus - offsite

With the existing conditions well documented and the priority established for consolidation of the storage areas, the next step was to establish the required functional flow as shown in Figure 7.4.

Following this it was necessary to establish the long range capacity and throughput requirements of the system. These were based on the following factors:

• Business Growth/Site Capacity

• JIT/Lot Size effects

• Make versus Buy

• MRP/Planning

• Peak activity levels

The effects of each of these factors were evaluated over a ten year period and the results are shown in Figure 7.5 for capacity and Figure 7.6 for activity.

CONTROL SYSTEM REQUIREMENTS - BLOCK DIAGRAMS

EXISTING FUNCTIONAL OVERVIEW :

CURRENT SLP AND RIDGEWAY FUNCTIONS SUMMARIZED AS FOLLOWS:

```
                                                    ┌──────────────┐
                                                    │ External      │
                                                    │ Warehouses    │
                                                    └──────┬───┬────┘
                                                           ^   │
                                                           ¦   v
┌──────────────┐                ┌──────────────┐    ┌──────────────┐
│ Receiving     │ ------------> │ Inspection    │ ----->│ Central   │ <----------
│               │               │               │ ----> │ Stores    │ <--------
└──────┬───────┘                └──────┬───────┘    └──────┬───────┘
       │                ┌─────────(1)──┘                   ^
       │                │   └──────────────────────┘       ¦
       │                │                                  v
       │         ┌──────────────┐                   ┌──────────────┐
       └-------> │ Engineering   │                   │ Assembly      │
                 │               │                   │               │
                 └──────┬───────┘                   └──────┬───────┘
                        │        (2)                        │
                        │         v                         v
                        └──────────────────────> ┌──────────────┐ <---
                                                  │ Shipping      │ <-----
                                                  └──────────────┘
```
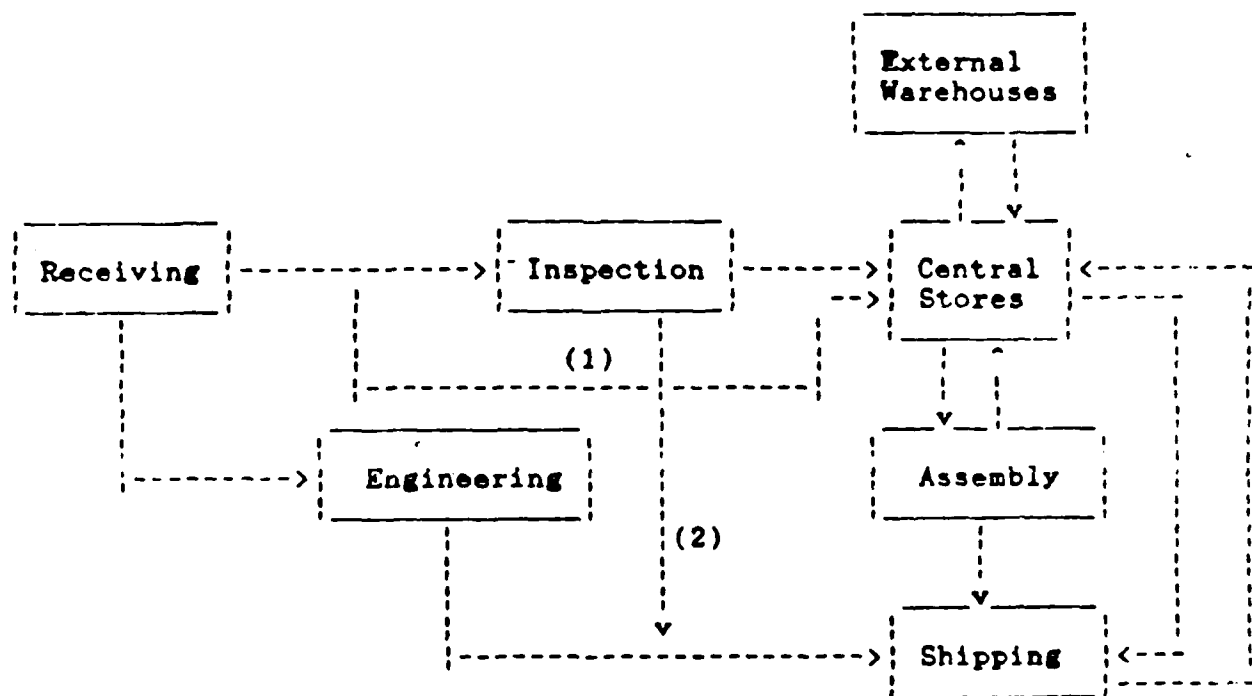
ALLOWABLE MATERIAL FLOWS ARE INDICATED BY DIRECTED ARROWS.

1: Non-certified material only
2: Rejected items being returned.

Figure 7.1 St. Louis Park As-Is Material Flow

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```
 |  A   ||  B  || C  ||  D  || E  || F  ||  G. ||  H  |
 1|              1986 STORES CUBIC VOLUME ANALYSIS
 2|           TOTABLE MATERIAL SUMMARY IN PRIORITY ORDER
 3|                (ST. LOUIS PARK MATERIAL ONLY)
 4|
 5| PRIORITY    STOCK              TOTAL    GROSS    NET    COMMENTS
 6| RANKING     CATEGORY           UNITS    CUFT     CUFT
 7|-----------------------------------------------------------------
 8|    1        MAIN STORES-MIL.     372    10430    3318
 9|    1        C ROOM STOCK          39     1032     988   With TSP Removed
10|    1        CAROUSEL STORAGE      63     1212     427   Without Kits
11|    2        MAIN STORES-COMM.     84     2646     854
12|    2        IRS CRIB              64     2101     675
13|    3        RECEIVING INSP.       78     1596     479
14|    4        W4 SURPLUS (WHSE)    195     6437    1868
15|    4        W7 TERM. (WHSE)       34     1071     299
16|    5        W5 SURPLUS (WHSE)     87     3157     625
17|-----------------------------------------------------------------
18| TOTAL                           1016    29682    9533
19|-----------------------------------------------------------------
```

```
 |  A   ||  B  ||   C  ||  D  || E  || F  ||  G  ||  H  |
 1|              1986 STORES CUBIC VOLUME ANALYSIS
 2|            BULK MATERIAL SUMMARY IN PRIORITY ORDER
 3|                (ST. LOUIS PARK PLANT MATERIAL ONLY)
 4|
 5| PRIORITY   STOCK               TOTAL    GROSS    NET    COMMENTS
 6| RANKING    CATEGORY            UNITS    CUFT     CUFT
 7|-----------------------------------------------------------------
 8|    1       C ROOM STOCK          14      309      309   With TSP Removed
 9|    2       IRS CRIB              12      531      531
10|    4       W4 SURPLUS (WHSE)     87     1566     1566
11|    5       W5 SURPLUS (WHSE)     35      630      630
12|-----------------------------------------------------------------
13| TOTAL                           148     3036     3036
14|-----------------------------------------------------------------
```

Figure 7.2 St. Louis Park Cubic Volume Analysis

```
  :   A   ::   B   ::   C   ::   D   ::   E   ::   F   ::   G   ::   H   :
 1:                         1988 DAILY ACTIVITY ANALYSIS
 2:                            ST. LOUIS PARK PLANT
 3:
 4:STORES SUMMARY:
 5:
 6:                    INSHIPS  STOCK     BOT      CG      TOTAL    COMMENTS
 7:                             RETURNS   LINES    TICKETS
 8:
 9:MAIN STORES-MIL.      87       78       470     1155     1790
10:MAIN STORES-COMM.     44       39        37       90      210
11:IRS STOCK            23        0       124        0      147
12:W4 SURPLUS STOCK      0       14        24        0       38
13:W5,W7 SURPLUS/TERM    0        0         0        0        0
14:                    ----------------------------------------------------
15:TOTAL DAILY TX       154      131       655     1245     2185
16:                    ----------------------------------------------------
17:
18:
19:RECEIVING INSPECTION SUMMARY:
20:
21:AVERAGE OF 30 HIGH PRIORITY LOTS /DAY        CURRENT =        30
22:AVERAGE OF 100 REGULAR PRIORITY LOTS/DAY     CURRENT =       100
23:TOTAL OF 130 LOTS/DAY                        CURRENT =       130
```
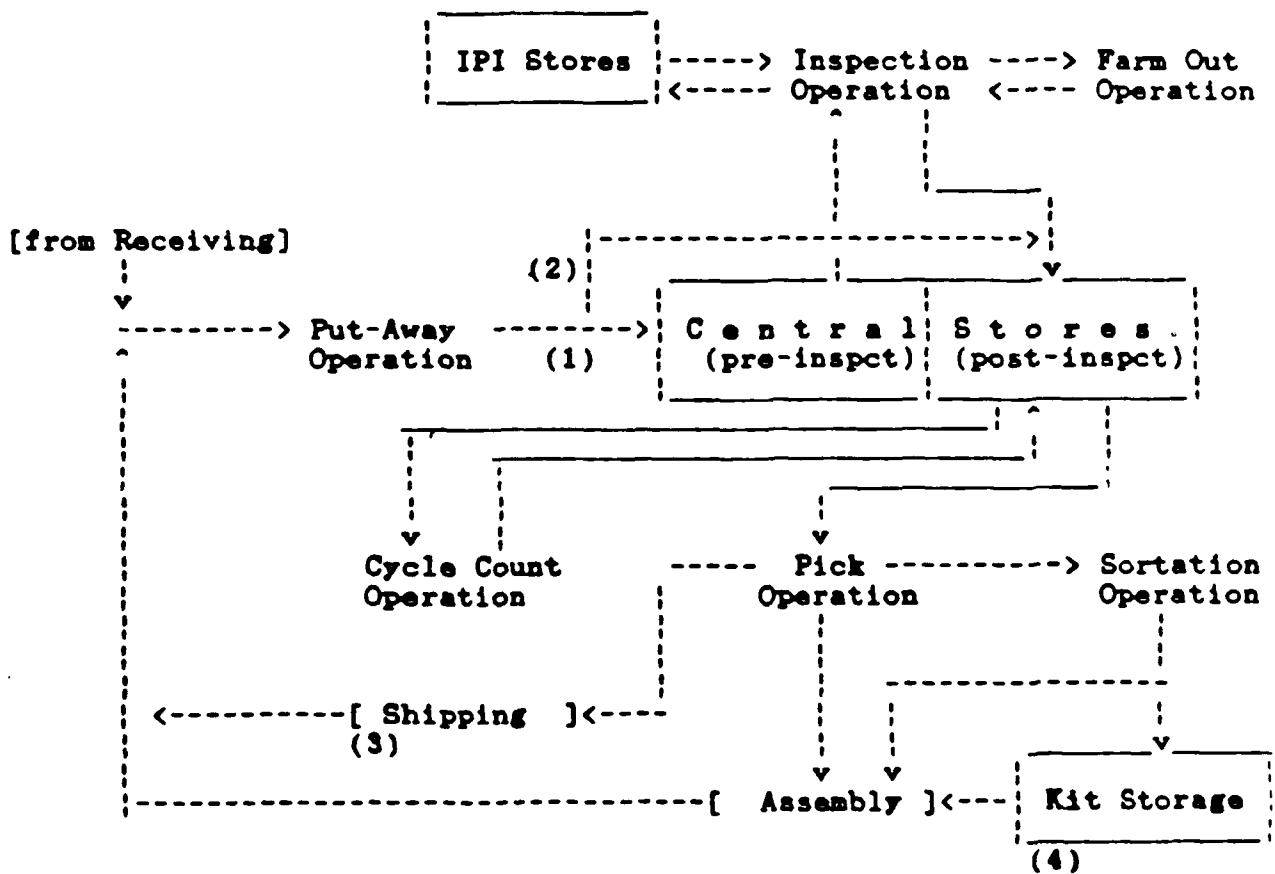
Figure 7.3 St. Louis Park Daily Activity Analysis

CONTROL SYSTEM REQUIREMENTS BLOCK DIAGRAMS

REQUIRED FUNCTIONAL FLOW

REQUIREMENTS FOR PLANNED OPERATION OF INSPECTION AND STOREOOM SUMMARIZED AS FOLLOWS:

```
                        ┌─────────────┐
                        │ IPI Stores  │-----> Inspection ----> Farm Out
                        │             │<----- Operation  <---- Operation
                        └─────────────┘                ^          ┊
                                                       ┊          ┊
  [from Receiving]                    ┌---------------------->┊    ┊
         ┊                    (2) ┊   ┊                       v    ┊
         v                        ┊   ┊  ┌──────────────┬──────────┐
  -----------> Put-Away --------> ┊ C e n t r a l │ S t o r e s . │
               Operation   (1)    │  (pre-inspct) │ (post-inspct) │
         ^                        └──────────────┴───────────────┘
         ┊                 ┌──────────────────────────┊    ^    ┊
         ┊                 ┊   ┌──────────────────────────────┊
         ┊                 v   v                ┌───────────────
         ┊            Cycle Count    ----- Pick ---------> Sortation
         ┊            Operation       ┊   Operation        Operation
         ┊                            ┊        ┊                ┊
         ┊                            ┊        ┊  ┌-------------------┊
         ┊     <----------[ Shipping  ]<----   ┊  ┊                   ┊
         ┊              (3)                    ┊  ┊                   v
         ┊                                     v  v            ┌─────────────┐
  -----------------------------------------[ Assembly ]<---│ Kit Storage │
                                                              └─────────────┘
                                                                    (4)
```

1: Certified material.
2: Non-certified material only.
3: Brackets [ ] enclose operations not part of MHS,
        shown for reference only. Enclosed boxes are MHS.
4: Kit Storage is physically separate storage area, optional item.

Figure 7.4 St. Louis Park Required Functional Flow

```
:  A   ::   B   ::   C   ::   D   ::   E   ::   F   ::   G   ::   H   :
36:                         FUTURE CHANGE FACTORS
37:
38:BUSINESS GROWTH/SITE CAPACITY =       +30%            1.3
39:JIT/LOT SIZE EFFECTS =                -10%             .9
40:MAKE vs. BUY =                        +5%            1.05
41:MRP/PLANNING =                         NC              1
42:PEAK INVENTORY LEVELS =               +5%            1.05
43:OTHER FACTOR TBD =                     NC              1
44:OTHER FACTOR TBD =                     NC              1
45:
46:
47:                1995 STORES CUBIC VOLUME PROJECTION
48:                TOTABLE MATERIAL SUMMARY IN PRIORITY ORDER
49:                     (ST. LOUIS PARK MATERIAL ONLY)
50:
51: PRIORITY    STOCK            TOTAL     GROSS     NET     COMMENTS
52: RANKING     CATEGORY         UNITS     CUFT      CUFT
53:-----------------------------------------------------------------
54:    1       MAIN STORES-MIL.    480     13454     4280
55:    1       C ROOM STOCK         50      1331     1274   With TSP Removed
56:    1       CAROUSEL STORAGE     81      1563      551   Without Kits
57:    2       MAIN STORES-COMM.   108      3413     1102
58:    2       IRS CRIB             83      2710      871
59:    3       RECEIVING INSP.     101      2059      618
60:    4       W4 SURPLUS (WHSE)   252      8903     2410
61:    4       W7 TERM. (WHSE)      44      1382      386
62:    5       W5 SURPLUS (WHSE)   112      4072      806
63:-----------------------------------------------------------------
64:  TOTAL                        1311     38287    12298
65:-----------------------------------------------------------------
66:
67:                1995 STORES CUBIC VOLUME PROJECTION
68:                BULK MATERIAL SUMMARY IN PRIORITY ORDER
69:                   (ST. LOUIS PARK PLANT MATERIAL ONLY)
70:
71: PRIORITY    STOCK            TOTAL     GROSS     NET     COMMENTS
72: RANKING     CATEGORY         UNITS     CUFT      CUFT
73:-----------------------------------------------------------------
74:    1       C ROOM STOCK         18       399      399   With TSP Removed
75:    2       IRS CRIB             15       685      685
76:    4       W4 SURPLUS (WHSE)   112      2020     2020
77:    5       W5 SURPLUS (WHSE)    45       813      813
78:-----------------------------------------------------------------
79:  TOTAL                         190      3917     3917
80:-----------------------------------------------------------------
```

Figure 7.5 St. Louis Park To-Be Capacity Requirements

	A	B	C	D	E	F	G	H
28			FUTURE CHANGE FACTORS					
29								
30	BUSINESS GROWTH/SITE CAPACITY =			+65%		1.65		
31	JIT/LOT SIZE EFFECTS =			+20%		1.2		
32	MAKE vs. BUY =			+5%		1.05		
33	MRP/PLANNING =			NC		1		
34	PEAK ACTIVITY LEVELS =			30%		1.3		
35	OTHER FACTOR TBD =			NC		1		
36	OTHER FACTOR TBD =			NC		1		
37								
38								
39			1995 ACTIVITY PROJECTION - ST. LOUIS PARK PLANT					
40								
41	STORES SUMMARY:							
42								
43		INSHIPS	STOCK	BOT	CG	TOTAL	COMMENTS	
44			RETURNS	LINES	TICKETS			
45								
46	MAIN STORES-MIL.	235	211	1270	3122	4838		
47	MAIN STORES-COMM.	119	105	100	243	567		
48	IRS STOCK	62	0	335	0	397		
49	W4 SURPLUS STOCK	0	38	65	0	103		
50	W5,W7 SURPLUS/TERM	0	0	0	0	0		
51								
52	TOTAL DAILY TX	416	354	1770	3365	5905		
53								
54								
55								
56	RECEIVING INSPECTION SUMMARY:							
57								
58	AVERAGE OF 30 HIGH PRIORITY LOTS /DAY				FUTURE =		81	
59	AVERAGE OF 100 REGULAR PRIORITY LOTS/DAY				FUTURE =		270	
60	TOTAL OF 130 LOTS/DAY				FUTURE =		351	
61	AVERAGE OF 60 FARMOUTS/DAY				FUTURE =		162	

Figure 7.6 St. Louis Park To-Be Activity

CRITERIA

The next step in developing the preliminary design was to establish a criteria for evaluating various types of equipment for storage, handling and control systems and software for operating the system.

EVALUATION CRITERIA

Equipment

- Flexibility - for reconfiguring the layout.

- High Density Storage - will provide efficient space utilization in low ceiling area.

- Modularity - for modification, expansion or relocation of the equipment.

- Expandability - for increasing the systems capacity.

- Speed - meeting required and peak activity.

- Reliability - low down time.

- Automation - level which can be justified by the ROI.

- Appropriateness - well suited for our application.

- Standard Item - requiring a minimum of customizing.

- Implementation - permit phased installation and startup.

- Support - established maintenance program.

- Reputation - for quality and performance.

- Human Factors - pleasant work environment, safe, easy to use.

Controls and Software

- Computer Equipment - appropriate to the application.

- Operating System/Implementation Language - adaptable to HMS/BOS.

- Custom versus Standard - software content.

- Support Requirements - training, commissioning, warranty.

- Price - projected relative cost to procure and install

ALTERNATIVES

The alternatives selected for evaluation were:

- Storage equipment

    1. Miniload AS/RS

    2. Carousel

    3. Carousel with robotic inserter/extractor

    4. Manned order picker trucks

    5. Existing method

- Handling System

    1. Conventional Conveyor System

    2. Transporter Conveyor System

    3. Automated Guided Vehicle System

    4. Side access Tote Stacker

    5. Existing Method

- Control System

    1. Fully controlled MHS System.

    2. Partially controlled MHS System - would control equipment but have little transaction processing software; would depend on HMS/BOS for database and transaction software.

    3. Minimal MHS System - would have local control of handling and storage equipment only, would have no transaction software.

The combination of hardware, computer equipment and software which best met our criteria were the following:

- Storage System - Carousel system with robotic inserter/extractors for each carousel.

- Handling System - Two-level tote conveyor system combined with transporters delivering totes to work stations.

- Control System - Full MHS System including a dedicated minicomputer and on-line interface to the HMS/BOS through CPL.

SELECTION CRITERIA

The following is the key criteria on which the selection was based:

- Carousel AS/RS with Dedicated Robots

    - - High throughput capability.

    - - Proven technology and low maintenance.

    - - Low manpower requirements.

    - - High density - low floor space requirements.

    - - Flexibility and modularity.

    - - Computer control capability.

- Two-level Tote Conveyor System

    - - High throughput capacity.

    - - Proven technology.

    - - Safety.

    - - Computer control capability.

- Full MHS Minicomputer System

    - - Stand alone capability.

    - - Custom features available

    - - HMS/BOS interface capability

    - - Implementation flexibility

    -- Less requirement for internal software development

DESIGN ALTERNATIVES

With the type of system determined, the capacity and throughput requirements established and the flow and control processes developed, several layout alternatives were considered and evaluated. The first design, shown in Figure 7.7 was thought to be the most effective for the area available in the building based on the following factors:
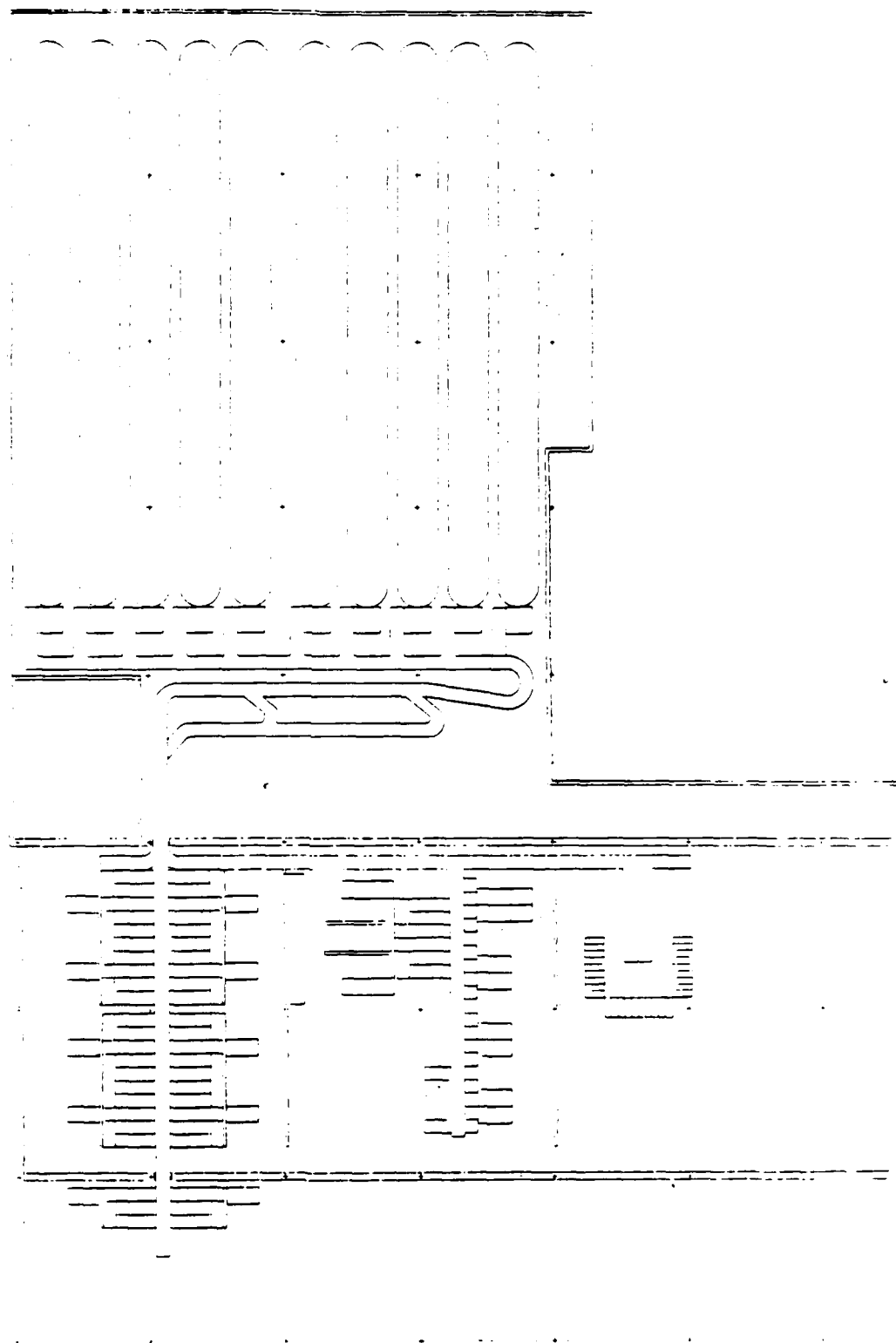
Figure 7.7 Preliminary St. Louis Park MHS Layout

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- Storage System space utilization and clearance - carousels provide high density storage under limited height ceilings.

- Noise control and isolation - carousels and conveyors separated from Inspection and parts stocking and picking by a block wall.

- Access to Receiving dock - Receiving stations located on the dock.

- Implementation flexibility - carousels would be installed in the vacated area and parts in stockroom transferred to carousels allowing Inspection to be installed in stockroom area.

A review of the preliminary design revealed a lack of space for support equipment in the Receiving Inspection area. A great deal of test equipment is located in the department in addition to the equipment at the Inspection stations. This situation was remedied by relocating the consolidation area and expanding the Inspection area into the space vacated by rerouting the Receiving Inspection conveyor. This is shown in the revised layout in Figure 7.8.

SIMULATION

Utilizing the revised design and developing specifications, a SIMAN Computer Simulation Model was developed. Using data developed during the design study and from the design specifications, a full series of simulation runs were performed on the proposed design

Each successive simulation run incorporated changes from the previous run to tune the system. The changes involved the number of operators required at workstations, the speeds of the various conveyors, tote separation on conveyors, tote queue sizes and certain critical control algorithms. This process was used to eliminate bottlenecks and excessive queue sizes encountered in earlier runs. A bottleneck at the outbound scanner was eliminated by increasing the speed of the two main conveyors and adjusting the scanner delay. See Appendix A for a detail description of the simulation.

SPACE DEFINITION

As the final design and specifications developed, it was necessary to establish the future availability of the area proposed for its installation. The area to be occupied by the Stores picking and stocking operations and Receiving Inspection are presently occupied by the stockroom so that area will remain available. However, the area proposed for the carousel storage equipment is presently occupied by the Commercial Printed Wiring Board (PWB) assembly operations which are expected to move out of the building early in 1988. This area is adjacent to the Military Printed Wiring Board assembly area which expects to expand after Commercial PWB assembly moves out. In order to accommodate Military PWB expansion, it was necessary to reduce our storage equipment from 10 carousels to 9 carousels. However, we are able to maintain our storage capacity by specifying 4 inch deep tote trays rather than 5 inch deep trays for a majority of our electronic components.
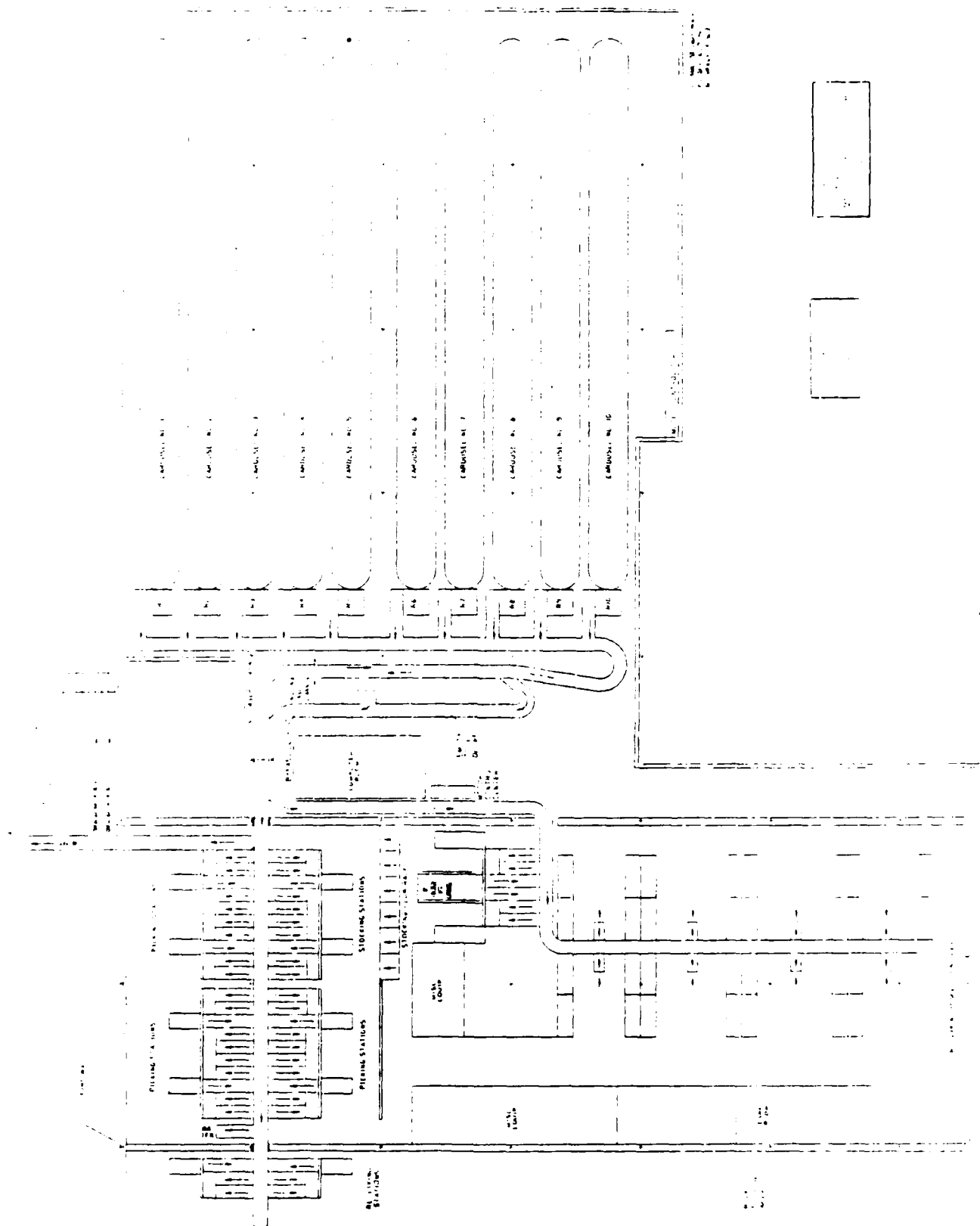
33

Figure 7.8 Revised Preliminary St. Louis Park MHS Layout

FINAL DESIGN

Another design revision was incorporated in the final design which will improve the service to the Military PWB assembly area. Presently, electronic components on reels are supplied to the auto-insertion machines from 3 manually serviced carousels adjacent to the PWB auto-insertion area. These carousels are located in the area planned for PWB expansion and where some of the proposed carousels will be located. Since they must be removed, one of the 9 remaining carousels will be designated for reel storage and the robotic inserter/extractor originally designated for the 10th carousel will be located at the end of the 6th carousel adjacent to the PWB auto-insertion equipment. This will permit computer controlled extraction of reels of parts at a work station which will supply these parts to auto-insertion.

This completed the modification of the system design and these changes are shown on the final design drawing (Figure 7.9).
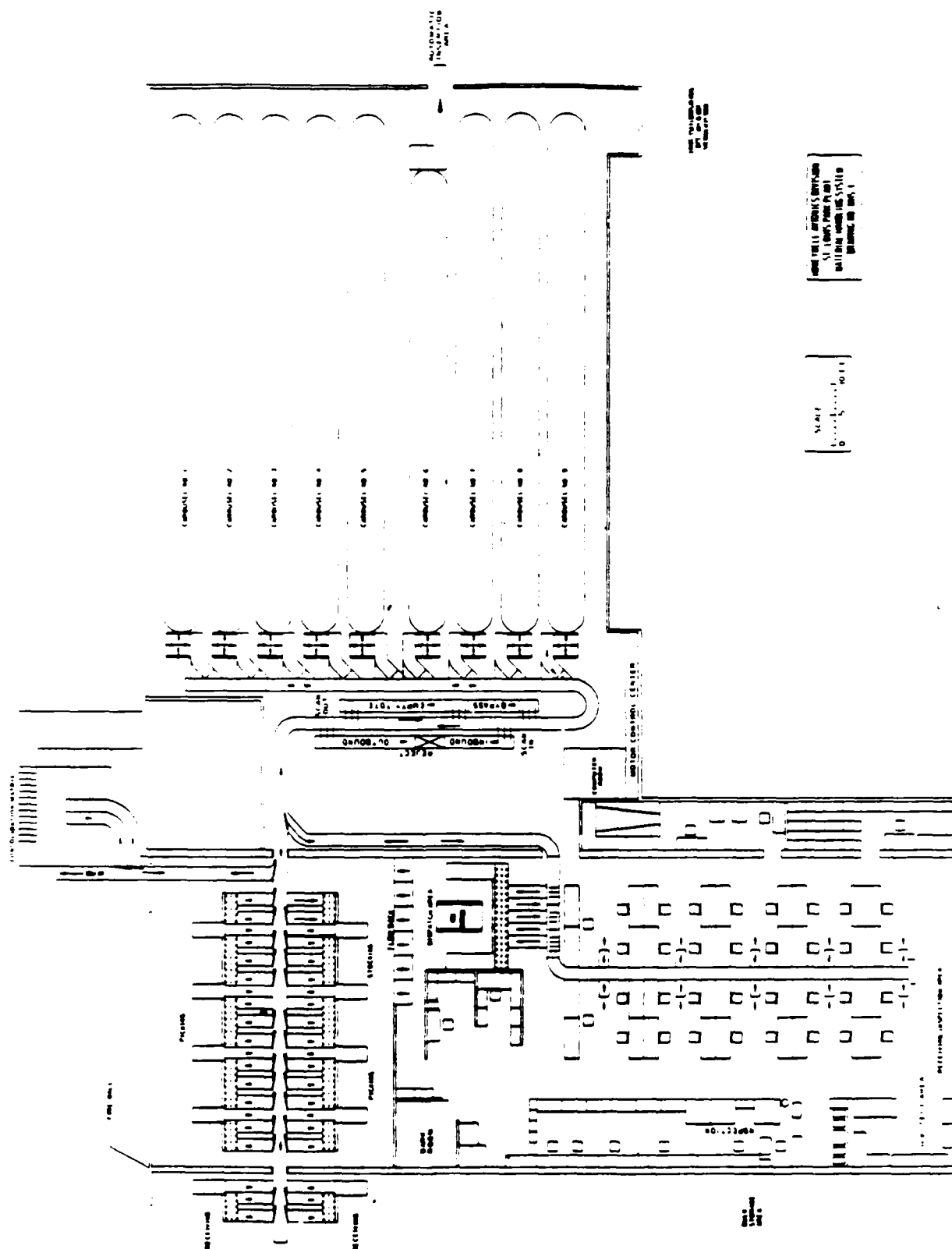
Figure 7.9 Final St. Louis Park MHS Layout

SECTION 8

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

INTRODUCTION

The Honeywell MAvD Handling System Automation Project was initiated to design a new state-of-the art automated system for the storage, retrieval and handling of material during Receiving, Receiving Inspection, Storage and Order Filling in the St. Louis Park Plant.

The project was initiated with the formation of a team of fourteen staff members with line management responsibilities for the areas of operation effected by the Material Handling System (HMS). The team was assisted by Independent consultants from Productivity Systems Inc., specialists in designing automated material handling and storage systems.

PRELIMINARY SYSTEM DEFINITION AND REQUIREMENTS SUMMARY

The first step in the development of the specifications for the new system was the preparation of a "Preliminary System Definition and Requirements Summary". The first draft (Revision 1) of the document contained a statement of the system objectives, the system requirements, a block diagram of the current functions followed by a block diagram of the functional requirements of the Proposed system and a description of the functional requirements for each phase of the process. The functions included were the following:

- Put-away Operations

- Central Stores

- Cycle Counting

- Inspection Operations

- Sortation Operations

It also contained sections on the following:

- Capacity Requirements - Stockroom

- Capacity Requirements - Inspection

- Report/Query Requirements

- Mainframe Link Requirements

- System Database - Consisting of:

  - - Inventory Items

  - - Inspection Procedures Instruction (IPI) Files

  - - Pending Put-a-way File

  - - Pick Request File

  - - Pending Inspection File

The concluding section was a System Overview describing the control elements, the data elements and the system operational procedures:

1. Receiving

2. Put-a-way Operations

3. Picks - Planned

4. Picks - Unplanned

5. Sortation Operation

6. Inspection

Revision 2

Various meetings were held with the project team to review and revise the specifications. The revisions included differentiation between materials in the HMS/BOS system and those not in the system. These were defined as Inventory Records Management (IRM) and non-IRM materials. It also addressed the handling of stock returns and incorporated a number of other additions and modifications.

Revision 3

Following a review of the second revision, a third revision was prepared which incorporated, in the material flow diagram, the inclusion of non-certified material flow and the separation of pre-inspected and post-inspected material in stock. The volume of activity in the stockroom and in inspection was increased to reflect the anticipated 1996 activity in the two areas. The list of Report/Query requirements was revised to include only those generated by MHS. This was the final draft of the specifications.

STORAGE HANDLING AND CONTROL SYSTEM SPECIFICATION

The next step in the preparation of the final design specification was the incorporation of portions of the "Preliminary System Definition and Requirements" into the first draft (Revision 1) of the design specification "Storage Handling and Control System Specification". This consisted of a "System Operating Description" section from the previous document and a partial draft of the "Process Control Computer System" containing subsections "Operating Description - Storage Functions" and "Operating Description - Order Picking". These sections describe various computer operations of the system.

Revision 2

The second revision of the design specification incorporated changes in the MHS Major Functions and Material Flow diagram and other changes throughout. It also contained an expanded "Process Control Computer System" description including General Requirements, System Hardware, Control System Software and Database Requirements.

Section 5.5 through 5.8 were expanded upon from the previous revision and the following sections added:

5.9   Operation Description - Cycle Count

5.10   Operating Description - Material Consolidation

5.11   Operating Description - Bulk Materials

5.12   Reports and Queries

5.13   System Performance

5.14   System Redundancy/Backup

5.15   Information Flow Diagrams

Revision 3

The third revision of the design specification added Section 1 "Scope of Work and Bid Requirements", Section 3 "Carousel/Robot AS/RS Specifications", Section 4 "Tote Conveyor Specification", and Section 6 "Honeywell MHS Design Parameters".

Section 1 Scope of Work and Bid Requirements

1.1   Scope of Specification

1.2   General Conditions of Contract

1.3   Project Quote Requirements

6.5   Work Station Requirements

6.6   Activity Requirements

This third revision, which covered most of the elements of the design specification, was thoroughly reviewed and further revisions made in preparation for the issuance of the specification to vendors for bids.
Revision 4

Revision four was then prepared incorporating suggestions made in the review of revision three and the subsections not previously incorporated. They were:

6.3   Storage Requirements

6.4   Conveyance Requirements

6.7   Building/Physical Requirements

7.0   "Glossary of Terms"

8.0   "Layout Drawings"

Addendum 1A

Revision four of the "Storage, Handling and Control Specifications" for the Material Handling System (HMS) Project was sent out with design drawings to seven vendors for bids. Section 9 of this report "Vendor/Industry Analysis/Findings" describes how the vendors were selected. Several of the vendors responded with questions on security access, the database, host communications and functions of the system. As a result of their request, an addendum 1A was
- prepared and sent out to the vendors along with a time extension for returning their bids. The addendum answered the questions presented by the vendors and clarified certain sections of the specifications the vendors did not understand.

When the bids were received they were carefully evaluated and the two vendors with acceptable bids, White and Eaton-Kenway, were asked to come in and present their systems to the Honeywell team. As a result of these sessions, further questions developed and other areas of the specification needed clarification.

Revision 5

After the bidders questions and concerns were satisfied, the resulting clarifications along with Addendum 1A were incorporated in revision five of the specifications. See Appendix B.

SECTION 9 ·

VENDOR/INDUSTRY ANALYSIS/FINDINGS

An industry survey was conducted to identify the companies that would be capable system supplier integrators. In general, there are numerous companies manufacturing and supplying system components, such as storage carousels, conveyor equipment and transaction software. There are also at least two dozen companies who claim to be "system integrators". These companies vary from divisions of major equipment suppliers, to small (a dozen employees) equipment sales organizations and startup software houses.

Successfully completing a complex systems project has proven to be a difficult task. It requires significant experience in making mechanical equipment and complex computer software work together - many system integrators seriously under-estimate the complexity and effort. Previous experience and careful research is required to identify those companies with truely successful track records.

After review and assessment of the companies active in this market, seven were selected as appropriate potential system suppliers for the Material Handling System (MHS) project. All seven were contacted by phone to discuss the project and solicit their interest in receiving the specification for review. All seven asked to receive the specification. They were selected based on the following criteria (not listed by priority or importance):

- Capability to supply prime contractor integration services.

- Size and financial stability (as indicated by Dunn & Bradstreet reports).

- Previous project experience in similar projects.

- In-house software and project management capabilities.

- Previously demonstrated attitude to work with the customer.

The seven potential system suppliers selected to bid on the project were:

Ann Arbor Computer - Division of Jarvis B. Webb Inc.
Ann Arbor, Michigan

SPS Technologies - Automated Systems Division
Hatfield, Pennsylvania

Honeywell - Manufacturing Systems Division
Phoenix, Arizona

White Data Systems - Subsidiary of White Storage & Retrieval Systems Inc.
San Diego, California

Raymond Corp. - Control Products Divi. jn
Hollister, California

Integrated Automation Inc.
Alameda, California

Harnischfeger Corp.
Milwaukee, Wisconsin

BIDS RECEIVED

Of the original seven potential suppliers, two (Harnischfeger and Ann Arbor Computer) declined to quote the project. Both were encouraged to reconsider, but indicated that it was their companies policy to not bid on jobs that did not have a high content of equipment they manufactured or supplied. The Honeywell MSD group chose to respond on a team basis with Eaton-Kenway Corporation, a leading supplier of large storage/retrieval systems, after requesting and being granted permission to do so. Eaton-Kenway was not included on the original potential supplier list because their business was in a different market - large stacker crane storage/retrieval systems for heavy loads. After the request to the team was received, it was learned that Eaton-Kenway planned to broaden their market to include systems for lighter loads and higher speeds, such as the MHS system. Initially, at least, the equipment they supply will be subcontracted to others in the industry. During the course of the bid process, Eaton-Kenway took the lead position on this team with Honeywell's MSD role becoming primarily a supplier of the control system components.

The remaining suppliers responded in the following manner:

SPS Technologies - Although their quote was for a complete system, SPS provided no detail or specific response to the MHS specification, even after repeated requests. Their position was that if they were selected for the contract, based on price alone which could vary by 20%, they would then send in a team to Honeywell to work out the details.

White Data Systems - White's proposal was complete and easily evaluated against the MHS specification in most areas.

Raymond Corporation - The response from Raymond was through one of their distributors, Johnson Equipment. However, it was for mechanical hardware only and in no way met Honeywell's request for a response to the complete MHS specification.

Integrated Automation - The response from Integrated Automation was incomplete. It covered only the computer hardware and software areas of the MHS specification. They supposedly would team up with Atlantic Material Handling Inc., but the response from Atlantic was not complete enough to evaluate.

SELECTION CRITERIA

The selection criteria for potential system suppliers consisted of several levels of response and evaluation. First, the MHS specification requested that suppliers quote the complete system as a prime contractor, on a fixed price basis. They were also directed to be completely responsive to the specification, itemizing exceptions or alternatives proposed. Price would certainly be a key evaluation point, but not the only one.

BIDS CONSIDERED

Based on evaluation of the bid responses from the remaining five potential suppliers, two more (Raymond and Integrated Automation) were eliminated because they would not provide quotations for the entire system and did not provide sufficient detail to allow serious evaluation of their proposals. They were eliminated only after several telephone conversations encouraging them to reconsider and submit a more complete response.

The remaining three potential system suppliers (Eaton-Kenway, White Data Systems and SPS Technologies) all provided quotations for the complete MHS system, in varying detail and style.

Although SPS provided a quotation for the complete system, they provided no detail or specific response to the MHS specification and no firm quote, even after repeated requests. Based on this response, their proposal was not competitive with the other responses and therefore was set aside.

The final two potential system suppliers, Eaton-Kenway (Honeywell MSD) and White Data Systems were rated according to an evaluation matrix by each Honeywell project team member.

EVALUATION CRITERIA

The evaluation of the final two system suppliers was based on a comprehensive 42 page Supplier Proposal Evaluation matrix (Figure 9.1). This matrix form itemized the supplier responses to each section of the specification. Each section response was rated as "As Req'd by Spec.", "Not Covered", "Exception Stated" and related comments. Twelve sets of matrix rating forms for each supplier were then reviewed and condensed into a final form. A detailed list of questions was developed for each and submitted to the suppliers to clarify certain points of their proposal. Responses were received and evaluated in further meetings. Each supplier was then invited to make a presentation to the Honeywell team and answer questions regarding their proposal. Each supplier was allowed a full day for the presentation. Approximately 12 representatives from Eaton-Kenway and Honeywell MSD attended the Eaton-Kenway presentation and 3 representatives from White Data Systems attended theirs. During the presentations, further questions were posed to each supplier, which they were requested to respond to in writing. Following the meetings, an all day review session was held by the project team.

Following the receipt of responses to our questions, detailed cost comparison spreadsheets for each proposal were prepared and reviewed (Figure 9.2). Final qualitative comparison ratings were developed, listing the strengths and weaknesses of each supplier and their proposal. A final Vendor Evaluation Pricing and Schedule Comparison matrix worksheet was prepared for each suppliers' proposal. This materials was reviewed by the entire Honeywell project team.

SUPPLIER PROPOSAL EVALUATION
SPECIFICATION SECTION 5.0   COMPUTER CONTROL SYSTEM

SUPPLIER

SPECIFICATION REQUIREMENT	PER SPEC. SECTION	AS REQ'D. BY SPEC.	NOT COVERED	EXCEPTION STATED	COMMENTS
PASCAL, C, OR OTHER LANGUAGE.	5.3.2	✓			
ADEQUATE DOCUMENTATION.	5.3.4		✓		Clarify
DATABASE STRUCTURES.	5.4.1	✓			
DOWNLOADING FREQUENCY AND COMMUNICATIONS INTERFACE.	5.4.2			✓	Clarify Pg F 9
DATABASE STRUCTURES AND FILE RECORD SIZES.	5.4.2-5.4.3	✓			
UPLOADING PROCEDURES AND COMMUNICATIONS INTERFACE.	5.4.4	✓			
RECEIVING OPERATIONS SOFTWARE.	5.5.1-5.5.12		✓		WDS could Clarify n Does Not Apply

Figure 9.1 Supplier Proposal Evaluation Matrix

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HONEYWELL HMS SUPPLIER EVALUATION: FINAL PRICE COMPARISON

FINAL Price Comparison: St. Louis Park Facility (12/15/86)

SPECIFICATION ELEMENT	WHITE DATA SYS.	EATON-KENWAY	COMMENTS
CAROUSEL EQUIPMENT	$387,083	$590,605	
ADD-ONS	$89,000		
CAROUSEL CONTROLS - LOCAL		$21,356	CONTROLS INCL. IN WHITE PRICING
VERTICAL CAROUSEL	$28,651	$30,246	
ROBOT EQUIPMENT	$507,236	$511,451	BOTH INCL. CONTROLS, APPARANTLY.
CONVEYOR SYSTEM - MECHANICAL	$218,421	$473,588	
ADD-ONS (22,000+3,850)	$25,850		
CONVEYOR SYSTEM - ELECTRICAL	$217,318	$429,451	INCLUDES SCANNERS, PLCs, PANELS, etc..
CONSOLIDATION MATRIX H/W &S/W	$71,000	$161,225	
WORKSTATIONS		$14,370	
CONTROL SYSTEM HARDWARE	$330,063	$230,564	
CONTROL SYSTEM SOFTWARE	$483,000	$443,794	
CONTROL SYSTEM INST. & INTEGR.	$60,000	$313,832	
CONTROL SYSTEM HMS INTERFACE	$44,000	$212,601	
PROJECT MANAGEMENT	$50,000	$177,264	
SITE SUPERVISION	$99,180	$108,125	
SPARE PARTS	$181,602	$98,985	
DOCUMENTATION & TRAINING	$27,500	$18,167	WHITE'S PRICE INCLUDES PREMIUMS AS REQUOTED
FREIGHT			NOT CLEARLY STATED IN EITHER PROPOSAL - ???
MECH. & ELECT. INSTALLATION - ALL EQUIP.	$274,533	$496,889	TOTALS - NOT BROKEN DOWN BY EITHER VENDOR.
WARRANTY COSTS	$58,600	$0	WHITE'S PRICE INCL. ADD-ON PREMIUM AS REQUO. J. E-K'S PRICE UPDATED PER 12/3/86 LETTER, P.4.
SOURCE CODE PREMIUM/LIC.	$10,000	$49,952	
180 DAY PRICE GUAR. PREM.	$94,891		E-K'S PRICE VALID FOR 180 DAYS.
PROPOSAL TOTAL:	$3,257,928	$4,382,445	

Figure 9.2 Project 28 Supplier Proposal Cost Comparison

EVALUATION RESULTS

1. The project team was very concerned about the suppliers' understanding of and attention to: details of the user functions; conveyor operation and noise level; proof of existing software that is appropriate to use as a basis for MHS; and an open and cooperative relationship.

2. Both potential suppliers were judged as needing close supervision during the implementation and installation of the project.

3. Eaton-Kenway was faulted for not being familiar enough with the specifications, for avoiding answering questions on their proposed software basis and for poorly coordinating their subcontractors.

4. Unanimous agreement was reached on the selection of White Data Systems as the preferred supplier during the final review meeting. The preference was very strong.

SECTION 10

MIS REQUIREMENTS/IMPROVEMENTS

Section five of the Specification "Process Control Computer System" covers the operating system and describes the Data Link Subsystem which is required to interface Honeywell's Manufacturing System (HMS) and Consolidated Pick List (CPL) with the Material Handling System (MHS). HMS will provide information from its PMC (Purchased Material Control) module for inshipping the material and will generate a data record for the material. This will be down loaded to MHS in an Expected Receipts File.

DATABASE REQUIREMENTS

Receiving

An expected receipts transaction is required. This is a transaction which is downloaded from HMS at the time the parts are received in order to identify incoming shipments and to have available in the MHS database sufficient information to complete the Receiving function. This information includes:

> Part Number
> Lot number (= inship number)
> Sub-lot Number
> Quantity (dock count)
> Date Received
> Warehouse
> Inspection Status
> Access Code (authorization level)
> Shelf Life Expiration
> To-Stock-Date
> Waiver Number

Inspection Process

The inspection process will be driven by the CRP (Capacity Requirements Planning) module of HMS which will create an Inspection Request File. This file will contain a record for each lot of material to be routed to the inspection area and a priority on the due date for each one. This file will be downloaded to MHS on a periodic basis. Results of the inspection operation will be recorded in a journal file record and uploaded to HMS.

Order Picking

Order picking will be done from a Pick List downloaded from HMS out of the CPL (Consolidated Pick List) module, which will run on the DPS-8 host computer. This list will be based on the planned withdrawals in due date sequence. This module will run once a night and generate order picking requirements for all orders that have been released by other HMS modules. The file will

be segregated into multiple Pick Lists, each with about 25 orders. Each Pick List will be sorted by order number and each order number will contain the exploded bill of material line items to be picked. Each line item on the Pick List will contain all the information necessary to pick the part, including the lot number. The parts list will be in FIFO sequence with the oldest lot chosen for that part number and warehouse. If an insufficient number of parts are available in the chosen lot or another lot, a shortage journal file entry will be uploaded to HMS and a backorder record created and maintained by MHS

The Pick Lists that are downloaded will also contain a number of information fields for each line item. This information will be printed on the Pick Ticket by MHS for future use in the assembly area. Once printed, these fields can be discarded. Hot Orders and Hot Picks will be downloaded in the same manner. Normally , the Pick Lists that are downloaded to MHS will be batched together prior to picking for operator efficiency. All communications between MHS and HMS will be performed on a real-time interactive basis as each activity is completed.

The following information is required for a pick order transaction:

    Order Number
    Requisition Item
    Warehouse
    Lot Number
    Date Inspected
    Part Number
    Quantity
    Order Move-To
    Due Date to Floor
    Operation Used-In
    Work Center of Operation
    Description
    Part Revision
    Part Modification
    Administration Center
    Unit of Measure
    Employee Identification
    Product Code and Description
    Assembly Material Item
    Issue Number
    Reference Number
    Waiver Number
    Lead Form
    Trace Code

Each pick, store, count and receipt transaction that is completed by MHS will require a specific completion record to be transmitted back to the HMS/CPL module. This feedback process should be able to transmit the completion records in real time or to a journal file (if the link is not available).

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The MHS system should be capable of handling the transactions on a frequent demand or asynchronous basis with transmission intervals on the order of minutes rather than hours. In this type of on-line communications, the data to be passed between the two systems would be queued in "transmission files" on each system and transmitted on demand or on request and received into similar transmission files. Background processing programs on each system would monitor the transmission files and control the data transmission and management functions.

Cycle Counting

Cycle count transactions may be initiated by HMS request or by the stockroom supervisor. The results will be transmitted to HMS with a transaction image written to the journal.

Information Feedback

Information to be fed back to HMS/CPL from MHS will normally be transmitted on a real time basis as each transaction is completed. If the communication link is not available, these transactions will be journaled to a mag tape for later transfer to HMS. The MHS activities that generate HMS feedback transactions are detailed as follows:

Stocking Transaction: Upon completion of each stocking transaction, a feedback record will be generated and transmitted to HMS/CPL.

Picking Transaction: Upon completion of each line item pick or hot pick, a feedback record will be generated and transmitted.

Unplanned Withdrawal: Any picks that are not generated by the HMS/CPL Pick List or Hot Pick transaction are designated as Unplanned Withdrawals. These will be entered via a keyboard transaction directly to MHS, and upon completion, require a feedback record to be generated and sent to HMS.

Unplanned Receipt: It is possible to receive material that has no in-ship record. This material will require keyboard entry of required information to MHS to stock the material. Items stocked in this manner require a feedback transaction to HMS/CPL.

SECTION 11

COST BENEFIT ANALYSIS

OVERVIEW

The savings resulting from the implementation of the Material Handling and Storage System (MHS) for Honeywell's St. Louis Park facility are grouped into four distinct areas:

- Dock/Inship area

- Receiving Inspection area

- Stockroom area

- Floor space

The CBA procedure is shown in Figure 11.1. The cost drivers and their associated savings have been determined for each area. The major cost driver for all areas is Material Handling labor. Department Supervisors for each area assisted Industrial Engineering in projecting personnel requirements. Methodologies used to determine the savings will be described for each of the three areas.

MANUFACTURING SCHEDULES

The manufacturing schedules for the St. Louis Park Receiving Inspection and Stockroom areas were determined to be the basis for the cost drivers and their associated savings. Activity data for Central Stores and Receiving Inspection was collected for two years (1985/1986). Data for the Stockroom consisted of picks and put-aways per month. Data for Receiving Inspection consisted of the number of lots inspected per month. The functions performed by the Production Control and keypunch operator in Receiving Inspection will be eliminated. The schedule clerk's function on the dock will also be eliminated by the MHS. As most of the project relates to Flight Systems Operations (FSO), ratios were developed between FSO revenue and Receiving Inspection and Stockroom activity. This ratio was applied to the 10 year FSO revenue projections obtained from FSO marketing to determine 10 year project activity levels.

1. DOCK/INSHIP SAVINGS

The average number of inships per month was calculated for 1985-1986, using data collected from the Dock/Inship Department. A ratio was determined for the quantity of inships to the personnel required. It was further determined that 25% of the effort on an inship was performed by a schedule clerk. With the implementation of the Material Handling System, the tasks performed by the schedule clerk would be eliminated.
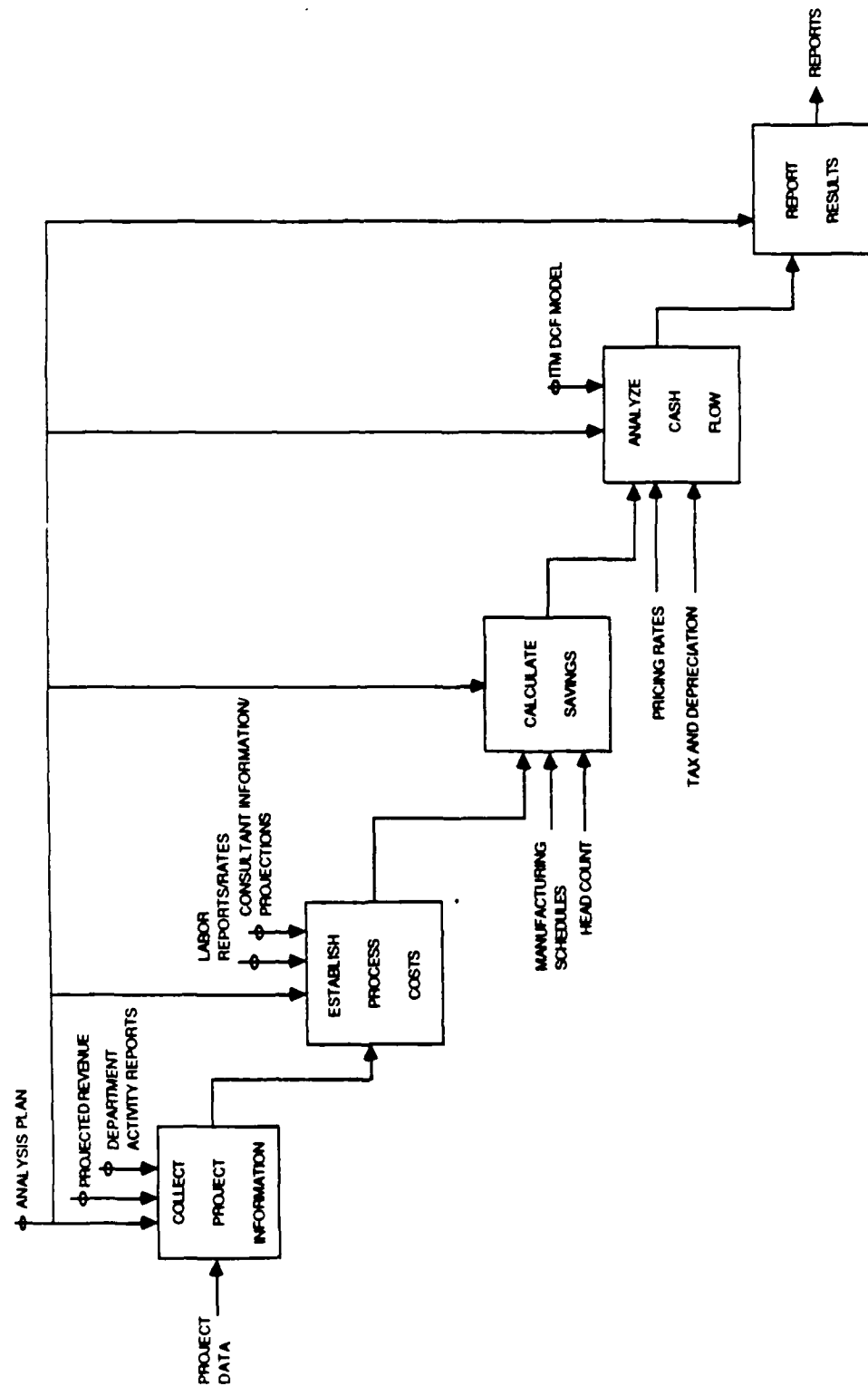
Figure 11.1 Cost Benefit Analysis Methodology

2. RECEIVING INSPECTION SAVINGS

The average number of lots inspected per month for 1985-1986 was collected from the Receiving/Inspection Department. To project the personnel requirements to meet the manufacturing schedules, a ratio was determined for the quantity of lots inspected to personnel requirements. With the implementation of the MHS, a 10% reduction in the Floor Inspector Crew will be achieved resulting from reduced time and labor spent on looking for and filing inspection folders, and searching for lots to be inspected .A Keypunch Operator's duties, consisting of entering inspection status from the "Inspection Data Input" form into the Mandate System, will be eliminated due to information based on direct line input to the computer by the inspector. The Production Control responsibilities, consisting of prioritizing and coordinating lots to be inspected, will be eliminated because all received material will be stored in a carousel.

3. STOCKROOM SAVINGS

Monthly transaction reports, consisting of picks and put-aways, were generated by the Stockroom Department for 1985-1986. These reports were used to project the personnel requirements to meet the manufacturing schedules. With the implementation of the MHS, a reduction in the Stockroom crew resulting from reduced labor in stocking and retrieving material, recording and data entry, and additional support functions will be achieved .

The MHS will permit tracking of in process inventory, which will reduce current manpower requirements for this function. The kit stage function will be performed primarily by the MHS sortation capabilities, reducing the manpower needs for kit staging. A VIP Tube Operator will not be required due to transactions being performed on-line with the MHS. One VIP Tube Operator will still be needed to input releases to the floor. The Automatic Insertion VIP Tube Operator function will be completely eliminated due to transactions performed on-line. One Group Leader will be eliminated with the implementation of the MHS as a result of time saved moving material and performing maintenance services. Due to the increased accuracy of picks and put-aways and reaction time of the MHS, there will be a decreased need for Hot Line Runners. The MHS quick reaction time and accuracy will also have a direct impact on the time required for picks and put-aways. The picking accuracy will increase to the 98% accuracy level, reducing labor spent on stock errors. An error report from the Stockroom Supervisor was used to determine stockroom error savings.

4 . FLOOR SPACE

The implementation of the MHS will have a positive impact on the floor space required for the Dock/Inship, Receiving Inspection and Stockroom areas. A reduction of 2400 sq. ft. in the St. Louis Park facility will occur.

TOTAL CAPITAL AND EXPENSES

The capital, recurring and non-recurring expenses for Project 28 are shown in Figure 11.2.

	Net Cost	6.00% Sales Taxable	9.75% Mat'l Acq	Gross Cost	Capitalization Date
CAPITAL COSTS					
Machinery Costs					
Horizontal Carousel	$504,853	$30,291	$49,223	$584,368	1988
Vertical Carousel	$30,382	$1,823	$2,962	$35,168	1988
Robots	$537,889	$32,273	$52,444	$622,606	1988
Conveyers	$489,483	$29,369	$47,725	$566,577	1988
Control Systems	$413,635	$24,818	$40,329	$478,782	1988
Consolidation Matrix	$75,291	$4,517	$7,341	$87,149	1988
Spare Parts	$192,576	$11,555	$18,776	$222,907	1988
Project Management (Vendor)	$53,022	NA	$5,170	$58,191	1988
Site Supervision (Vendor)	$105,174	NA	$10,254	$115,428	1988
Installation (Vendor)	$291,123	NA	$28,385	$319,508	1988
PSI Management Fee (Consultant)	$90,000	NA	$8,775	$98,775	1988
Computer Room Mat'l (HI)	$8,000	$480	$780	$9,260	1988
Area Preparation Mat'l (HI)	$174,000	$10,440	$16,965	$201,405	1988
Tote Trays	$300,000	$18,000	$29,250	$347,250	1988
	-------	-------	-------	-------	
TOTAL MACHINERY COST	$3,265,428	$163,567	$318,379	$3,747,374	
Furniture Costs					
Receiving Insp Benches	$72,000	$4,320	$7,020	$83,340	1988
TOTAL CAPITAL COSTS	$3,337,428	$167,887	$325,399	$3,830,714	
EXPENSE COSTS					
Non-Recurring Expenses					
HMS Interface (Consultant)	$44,000	NA	$4,290	$48,290	
Source Code Premium/Lic	$10,000	$600	$975	$11,575	
Documentation & Training (Vendor)	$27,500	NA	$2,681	$30,181	
Computer Room Labor (HI)	$8,000	NA	NA	$8,000	
Area Preparation Labor (HI)	$348,500	NA	NA	$348,500	
Software	$483,000	$28,980	$47,093	$559,073	
HI Direct Labor	$10,000	NA	NA	$10,000	
	-------	-------	-------	-------	
TOTAL NON-RECURRING	$931,000	$29,580	$55,039	$1,015,619	
TOTAL CAPITAL + NON-RUCURRING	$4,268,428	$197,467	$380,438	$4,846,333	
Recurring Expenses					
* Annual Maintenance (Mechanical)	$34,000	NA	$3,315	$37,315	
* Annual Maintenance (Computer HW)	$41,600	NA	$4,056	$45,656	
* Annual Maintenance (Computer SW)	$15,000	NA	$1,463	$16,463	
	-------	-------	-------	-------	
TOTAL RECURRING	$90,600	NA	$8,834	$99,434	

* Expense starts in year 2.

Figure 11.2 Project 28 Expenditure Schedule

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this project ($15,467,667) will start occurring in the third quarter of 1989 and continue through the second quarter of 1999. This equates to an IRR of 28% which exceeds Honeywell's Military Avionics Division hurdle rate of 26%. The Projects cash flows are shown in Figure 11.3 with the assumption that capital is available in 1988.

PROJECT CASH FLOW SUMMARY
($000)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Capital	$3,831	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$3,831
Non-Recurring Expense	$1,016	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,016
Related Expenses	$0	$0	$50	$99	$99	$99	$99	$99	$99	$99	$99	$50	$895
Savings	$0	$629	$1,207	$1,203	$1,154	$1,295	$1,427	$1,576	$1,742	$1,926	$2,130	$1,178	$15,468
Depreciation	$378	$682	$547	$439	$352	$283	$228	$260	$260	$260	$133	$7	$3,827

Figure 11.3 Project 28 Cash Flows

SECTION 12

IMPLEMENTATION PLAN

INTRODUCTION

The proposed Implementation Plan is based on the assumptions that Capital Funds for the project will be incorporated in the 1988 Capital Plan, that funds are available during the first quarter of 1988 and the 28% IRR is acceptable to Honeywell management. It also assumes that the space presently occupied by the Commercial Aviation Division's printed wiring board assembly area will be vacated during the first quarter of 1988.

DESCRIPTION OF IMPLEMENTATION PLAN ACTIVITIES

The following is a description of the activities shown on the Project 28 Implementation Plan Schedule (Figure 12.1).

BUILDING PREPARATION

Design of the Area - This is a Plant Engineering activity which consists of preparing plans for the construction of the area in which the MHS and Receiving Inspection will be located. It will involve the planning of the removal of existing walls, the location of offices, utilities, etc.

Demolition of the Area - When the project funds are approved and the Commercial Aviation Division has vacated the area, the Maintenance Department will begin the removal of existing internal walls, ceilings and other obstructions to the installation of the MHS.

Construction of the Area - This involves the construction of new offices, refinishing of existing walls and installation of utility outlets where required.

PLANNING

Facilities and Project Management Requirements - Before the project can be started, the location of the system and the facilities requirements must be finalized and agreed to by Plant Engineering, the Honeywell Project Manager and the supplier Project Manager.

Project Schedule - These same parties must establish and agree to a project schedule with milestones and a method of monitoring progress against the established milestones.

DESIGN

Functional Design Documents - Based on Honeywell's specifications, the supplier shall develop a Functional Design document as required by Paragraph 1.5.3 of the Honeywell specification and a System Detailed Design Document as required by Paragraph 1.5.4 (see Appendix B). The latter shall include among other sections, system application software, design documentation, diagnostic procedures and a software implementation schedule.

ACTIVITY	1988										1989				
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Building Preparation															
Design of Area	XXXX	XXXX													
Demolition		XXXX	XXXX												
Construction				XXXX	XXXX	XXXX									
Planning															
Facility & Proj Mgt Req	XXXX														
Project Schedule	XXXX														
Design															
Functional Design Doc	XXXX	XXXX	XXXX	XXXX											
Detailed Spec		XXXX	XXXX	XXXX	XXXX										
Develop Accept Test Doc					XXXX	XXXX									
Software															
Control Sys S/W Gen				XXX	XXXX	XXXX	XXX								
Control Sys S/W Customization						XXX	XXXX	XXXX	XXXX						
S/W Integ @ Vendor Facility									XXXX	XXXX					
S/W Demo @ Vendor Facility											XX				
Hardware															
Procure Components				XXXX	XXXX	XXXX	XXXX								
Mech & Elec Install in Stockrm								XXXX	XXXX	XXXX					
Mech & Elec Integ in Stockrm											XXXX				
Mech & Elec Install in Inspec												XXXX			
Mech & Elec Integ in Inspec													XX		
Integration & Testing															
Software Integration															
Stockroom											XXXX	XXXX			
Receiving & Inspection													XXXX		
System Integration & Test											XXXX	XXXX	XXXX	XXXX	
Operator & Maint Training											XXXX	XXXX	XXXX	XXXX	
System Acceptance Testing														XXXX	XXXX
Final Acceptance															X

Figure 12.1 Project 28 Implementation Plan

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Detailed Specifications and Drawings - The detailed specifications, design and installation drawings will be prepared by the supplier and approved by Honeywell.

Develop Acceptance Test Documentation - Acceptance test documentation will be developed based on the requirements of the Honeywell specifications.

SOFTWARE

Control System Software Generation - The supplier will generate the standard Control System software necessary to operate the MHS equipment.

Control System Software Customization - The supplier will customize the Control System software to meet the unique requirements of the Honeywell system (i.e. CRT screen format, labels, reports, queries, etc).

Software Integration at the Suppliers Facility - The supplier will integrate the control system hardware and software at his facility prior to shipment.

Software Demonstration at Suppliers Facility - The supplier will demonstrate the control system hardware and software to Honeywell personnel for approval at his facility prior to shipment to Honeywell.

HARDWARE

Procure Components - Based on the Honeywell specifications and the suppliers detailed drawings and specifications, orders shall be placed for the fabrication of the necessary carousels, robots, conveyors, support equipment and controls.

Mechanical and Electrical Installation of Receiving and Stockroom Equipment - All carousels, robots, conveyors and work stations associated with the receiving and stockroom operation shall be installed mechanically and electrically in the specified locations in the St. Louis Park facility. The installation will be in accordance with the detailed installation drawings and under the direction of a full time installation supervision furnished by this supplier.

Mechanical and Electrical Integration of Receiving and Stockroom Equipment - Once installed, the various components of equipment shall be integrated with the computer controlled system and the storage equipment so that Receiving and the stockroom can function prior to relocation of Receiving Inspection.

Mechanical and Electrical Installation of Inspection Handling Equipment - Following removal of shelving from the stockroom, the conveyor, dispatch stations and inspection stations shall be installed mechanically and electrically in this area in accordance with the detailed installation drawings. The installation will be under the direction of a full time installation supervisor furnished by the supplier.

Mechanical and Electrical Integration of Inspection Handling Equipment - When the handling equipment has been installed, it shall be integrated with the compuier controlled system.

INTEGRATION AND TESTING

Software Integration of Stockroom - When the suppliers stockroom system is operational and delivered, it will be integrated with the Honeywell computerized operating system.

Receiving and Receiving Inspection - When the suppliers receiving inspection handling system is operational and delivered, it will be integrated with the Honeywell computerized operating system.

System Integration and Testing - With the handling equipment in both the stockroom and receiving inspection integrated with the operating system, the complete system will be operated and tested against the operating test document. At this time, the Receiving Inspection support equipment will be relocated into the new area and Receiving Inspection will be performed using the new handling system.

Operator and Maintenance Training - During the integration of the hardware, the control software, and the operating system, both maintenance and operating personnel will be trained on the maintenance and operation of the system.

System Acceptance Testing - The complete system will be operated to perform all of the functions required in the Acceptance Test Documentation.

Final Acceptance - Based upon the satisfactory performance of the complete system against all of the requirements of the Acceptance Test Documentation, the system will be accepted by Honeywell and the one year warranty period will begin.

SECTION 13

PROBLEMS ENCOUNTERED AND HOW RESOLVED

DETERMINATION OF STORAGE CAPACITY REQUIREMENTS

When this project was first initiated, the St. Louis Park Plant included production facilities for the Test Systems and Logistics Operations (TSLO) and the Commercial Aviation Division (CAvD). As the project progressed, TSLO was moved out of the building and CAvD will be moved out of the building before the Material Handling System (MHS) is installed. This presented a problem in determining the storage capacity required at the time of installation.

RESOLUTION

After TSLO moved out of the St. Louis Park facility, the storage capacity requirements were reviewed and the stockroom requirements of TSLO removed from the total capacity requirements. In tabulation of the stockroom storage capacity, CavD stock was designated separately so these figures could be removed to adjust to the future requirements.

SPACE REQUIREMENTS

The original space plans and layouts were based on occupying all of the CavD Printed Wiring Board (PWB) Assembly area plus the present carousel area where reels of components are stored for auto-insertion. In finalizing these requirements with Plant Engineering, it was necessary to deal with a request from the Military PWB Assembly area for future expansion capability equivalent in space to the present carousel room. Since this room occupies a significant section of the area we planned for the new carousel installation it was necessary to work out a compromise agreement without losing that space.

RESOLUTION

Since the expansion needs of the PWB area had to be adjacent to their existing space and their area was restricted on the south by an aisle, on the north and west by our proposed carousel storage area, and on the east by an adjoining assembly area which could not be reduced, a compromise solution was difficult to arrive at. However, by rerouting the south aisle to the outside wall of the building and giving up the space which one carousel was planned to occupy, the necessary area could be made available. This reduced the number of carousels from 10 to 9 and thus reduced the overall tote capacity of the MHS. However, it was determined that we could reduce the height of our principle tote from 5" to 4" thus increasing the number of totes that could be installed in the remaining carousels by nearly 25%. This more than compensated for the lost carousel and allowed us to dedicate one carousel to reeled parts storage. In addition, the 10th inserter/extractor robot (from the carousel removed) was relocated at the opposite end of carousel #6 where it can deliver trays of reels directly to the auto-insertion area (see Figure 7.9).

HMS INTERFACE WITH MHS

In order to develop a software system to interface with the Honeywell Manufacturing System (HMS), it was necessary to determine what information had to be transmitted between the main frame and the Material Handling System (MHS). HMS, which is scheduled to be in operation by the time the Material Handling System is operational, had no stockroom module. Therefore, there was no way of knowing what information would be received from HMS and what information had to be transmitted back to HMS.

RESOLUTION

It is necessary to solve this problem in order to operate under HMS prior to the installation of the Material Handling System. This involved writing an inventory control module (Consolidated Pick List "CPL") for HMS and taking into consideration the requirements for the MHS. As a result, Section 5 of the specification (Appendix B) describes the database requirements for each of the transactions and the master record files required to be resident on the MHS System.

SECTION 14

AREAS FOR FUTURE CONCERN/DEVELOPMENT

FUTURE CONCERNS

Storage Requirements

The proposed Material Handling System (MHS) has been designed to handle Receiving, Receiving Inspection and stockroom activity and storage requirements over a 10 year period. However, future operating system changes may change the activity in the departments serviced by this system. Therefore, by continuing to follow our original projections, proposing a flexible, modular system, we will be able to accommodate variations in the capacity and activity requirements of the production areas.

FUTURE DEVELOPMENTS

PWB Distribution System

When Project 28 is installed adjacent to the Military Printed Wiring Board (PWB) Assembly area, reels of components will be delivered off a carousel directly to the auto-insertion area. The balance of the parts for this assembly area will be kitted in the consolidation matrix area of the automated stockroom. Since approximately 80% of the output of the stockroom is used in the PWB Assembly area, mechanizing the delivery of kits from consolidation to the input station of the CS/RS in this area would eliminate a very high proportion of deliveries made throughout the building. This mechanization has already been considered and will be investigated in detail when the present project has been installed.

St. Louis Park Distribution System

Tech Mod Project 27, which is on hold, was for automating the inter-area material handling function at the St. Louis Park facility. All inter-area material handling is performed manually or with manually - guided material handling equipment. Since distances between areas are relatively long, labor cost of material handling is significant.

The automated system would have connections between stores and production and between production and packing/shipping. The benefits derived from the system are significant reductions in labor costs and improvements in material control and leadtimes.

APPENDIX A

SIMULATION MODEL

MODEL PURPOSE AND OBJECTIVES

The Material Handling System (MHS) proposed for Honeywell's St. Louis Park facility is a complex automated material handling and storage system with real-time computer control. In order to validate the design, configuration, capacities, and operational behavior, it was decided to build a detailed computer simulation model. The purpose of the simulation model is to accurately predict the dynamic behavior of the system under normal and full load conditions, taking into account the various system variables and dwell times. The complexity of these precluded a simpler hand analysis, which is usually not sufficient for systems such as this. Previous experience has proven that a detailed computer simulation with quantitative statistical evaluation is inexpensive "insurance" for a correct system design. An additional benefit is that in order to build a simulation model, a detailed and exhaustive study must be made of all design assumptions, requirements, and data process that often is not completed.

The simulation model was constructed in order to determine several factors in the design and operation of the MHS system, as it is currently proposed, including the following:

- Carousel/Robot system throughput and utilization.

- Tote conveyer system througnout and utilization.

- Inbound, outbound, and bypass tote queue utilization/requirement.

- Tote conveyer system speed requirements.

- Empty tote lane requirement and utilization.

- Work station and operator requirements and utilization.

- Potential bottlenecks in tote queues or system resources.

- Validation of required throughput for current operations.

Analysis of the simulation model results (various experiments and simulation runs) was then used to modify the physical configuration planned for the MHS system, modify the logical operation and control system requirements, and modify the operational plans and procedure for the system.

MODEL STRUCTURE AND LANGUAGE

The simulation model was developed and written in SIMAN (for SIMulation ANalysis), version 3.1. SIMAN is one of the most powerful simulation languages and run time systems available today, and it has special features for modeling material handling systems. Additionally, the full language can run on the IBM PC/XT and AT line of computers. The model consists of a Problem Statement, the Data and Parameters Definition, a Configuration Diagram, the Model Description expressed in SIMAN modeling terms, and the Run-Time Model and the Experimental Frame code.

The SIMAN model was constructed to model the major MHS system elements each as a separate submodel, which could be modified and observed within the overall system environment. The model included the following fourteen submodels:

- Order generation process.

- Station request process for work totes and empty totes.

- Empty tote lane process.

- Outbound conveyer scanner and queue process.

- Inbound conveyer scanner, queue, and bypass process.

- Two outbound inter-conveyer transfer processes.

- Two inbound inter-conveyer transfer processes.

- Ten Carousel/Robot pair processes.

- Twelve Picking station processes (stations 1-12).

- Four Stocking station processes (stations 13-16).

- Two Receiving station processes (stations 17-18).

- Two Inspection dispatch station processes (19-20).

- Ten Inspection station processes (21-30).

- Two Sortation and consolidation station processes (31-32).

The complete model is stored on diskette, and is executed through running SIMAN on an IBM PC/XT or AT with a math co-processor chip. Disk Operating System (DOS) version 3.10 was used to allow compatibility with the AT computer.

MODEL DATA AND VALIDATION

The specific data that was required for input into the simulation model was extracted from the MHS Design Study and final System Specification, production records, and input from experienced personnel at the St. Louis Park plant. The production records for the stockroom and inspection operations were examined, stockroom activity observed and counted, and projected requirements were constructed. Information developed from this process was used to determine the following input to the model:

- Order picking requirements and batching factors.

- Per-shift receiving and stocking operation requirements.

- Dwell times - min, max, and probability distributions - for the following:

  - - Picking operation

  - - Receiving operation

  - - Stocking/detrash operation

  - - Inspection dispatch and return operation

  - - Inspection operation

  - - Sortation and consolidation operation

- Success/failure probabilities for inspection operations.

- Work station assignments and numbers.

Additional data for the simulation model was developed from other sources, including the following:

- MHS system layout and drawings.

- Probability distribution studies for several key areas, including the number of line item picks per tote (given a batching factor), abnormal dwell time incidents, etc.

- Typical equipment operation and speed for conveyers, carousels, robots, etc.

- Analysis of key system control algorithms, such as carousel rotation optimization.

- Queue size constraints for the workstation design and conveyer accumulation areas.

- The number of operators per shift for the various station types.

- Detailed discussions with key personnel in the stockroom and inspection areas.

The model structure and operation was validated through an interactive run-review-modify process. The model was run in "step mode" to observe representative transactions and movements for each submodel to verify that tote movements and delay times were occurring as expected, that the dispatching and routing logic was being properly followed, and that statistical counters were being properly incremented. The results of the initial runs were carefully analyzed and logical inaccuracies were corrected.

In order to make simulation of a system with this level of complexity feasible there are a number of approximations or simplifications of the data and requirements that must be included. Based on detailed analysis and feedback from the project team, and the test of reasonableness from previous experience, we feel that the model and the data used for the simulation model and experimental runs are sufficiently accurate and complete to allow conclusions to be made regarding the functionality and design features of the final system design.

PROBLEM STATEMENT

The problem is to model the operation of the proposed MHS system, which is a carousel/robot based central storage system utilizing a standard size, conveyable tote container. The system consists of a carousel based AS/RS, tote delivery conveyor system with bypass and empty tote loops, 34 workstations (tote delivery and return), and a sortation area with 2 tote delivery queues.

The system supports five major functions that we will be concerned with in the simulation: Receiving Put-away, Inspection Dispatch, Stocking (permanent storage), Order Picking, and Order Consolidation. The problem is to model the tote selection, routing and traffic, accumulation and queue delays, and operator processing delays encountered while processing simulated work order demands for these functions. Additionally, the key system software algorithms will be incorporated into the model. The following sections describe the aspects of each of these major functions that must be modeled and simulated.

Receiving Put-Away

Items to be sorted in MHS arrive at one of two stations designated as a Receipts station. They arrive randomly throughout the first shift each day. Items wait in a manual storage area (not modeled) for an available operator. They then encounter a processing delay, are placed into a storage tote, and are conveyed to the carousel AS/RS for (random) storage. More than one item can usually be stored in a single tote. Empty totes are required for this operation, and are removed from an inbound queue position at the station. The system always attempts to keep this queue full. The Receipts process operates on a single shift per day basis.

Inspection Dispatch

Inspection request orders are generated (by the HMS mainframe) on a random basis, which call for Receipted items to be sent from carousel AS/RS to one of the (two) active Inspection Dispatch stations. They are conveyed to the dispatch station where they enter the inbound tote queue and wait for the dispatcher to be available. They then encounter a processing delay while the dispatcher processes the transaction (which includes the Inspection Procedure Instruction

"IPI" folder picking delay), removes the item from the stores tote, places it into a dispatch tote, moves the stores tote to the outbound conveyor queue for automatic return back to the carousel AS/RS, and finally moves dispatch tote to the outbound tote queue. When space is available on the conveyor, it is then conveyed, via the bypass loop, to an inspection workstation with available space in its inbound tote queue. The inspection item waits there until an inspection operator is available. The item is then delayed for the inspection process and then placed into the outbound tote queue at the work station. When space is available on the conveyor, the tote is conveyed, via the bypass loop, back to an inspection dispatch station with space available in the inbound tote queue.

When the dispatcher becomes available, the tote is then delayed for the dispatch return process (which includes a delay for returning the IPI folder). A certain percentage of the returned items have passed inspection and are moved manually to a tote in a flow rack storage device (not modeled), where they await an available Stocking operator. The remaining percentage of the returned items have not passed inspection, and are placed into a storage tote and moved to the outbound tote queue for conveyance back to the carousel AS/RS. This operation requires either an empty tote, a tote of the correct warehouse type with available space to be available at the station, or conveyed from AS/RS before the operation can complete. The inspection operation works on a two shift per day basis.

Stocking

The Stocking process is driven by items arriving at one of the designated Stocking stations to await a Stocking operator. Items arrive either from the inspection dispatcher station(s), or as Material Transfers (other receipts) from other plant operations. In either case, the items arrive via manual transfer to a holding area (not modeled). When a Stocking station operator is available, they will process the items, one at a time. The processing delay incurred will depend on whether the operation is a Material Transfer, which has a longer delay, or an inspected item stocking operation, which has a short processing delay. Some percentage of the items to be stocked can be placed into a storage tote still held at the station; the remaining items require a tote to be called for and conveyed from the carousel AS/RS before the transaction can be completed. Once completed, the tote is moved to the outbound tote queue. When space is available on the conveyor, the tote is conveyed to the carousel AS/RS for storage in a random location. The Stocking operation runs on two shifts per day.

Order Picking

Picking Orders, including Hot picks and cycle counts, are generated in groups (by the Honeywell mainframe) and fed to the MHS system, where they are held until processed and completed. In this model we assume that there is always a queue of pending Pick Orders (an infinite number of requests). The model will therefore always attempt to route an Order to every active Picking station with space available in its work queues. We can also assume that whenever Batch Picking is enabled, the line items required for each Pick Order will be picked in batches, averaging in size equal to the Batching Factor. Each Pick Order will have a number of line items to pick. A certain percentage of the Pick Orders will be generated with only a single line item - these are Hot Picks.

The Order picking process then operates as follows. As an operator at a Picking station becomes available, they remove the next Order from their (logical) work queue. Storage totes from the carousel AS/RS are retrieved and conveyed to the station from random locations. As each of these is moved from the head of the inbound tote queue, a "picking" delay is encountered while one or more (depending on the batching factor) line items are picked. When the required number of line items for this Order have been picked, the Order is completed, and the performance data is recorded. Items that are picked are placed into a different tote. When a certain number of picked items are placed into this tote, it is considered full, and is moved to the outbound tote queue and conveyed to the Sortation area. A supply of empty totes must be available at the Picking station for these items. The empty totes are conveyed when called for from the AS/RS, and delivered into an inbound tote queue reserved for empty totes. The system will always attempt to keep this queue full.

This picking process continues as described at each Picking station until the station becomes inactive (e.g., from a break or shift change).

Order Consolidation

Items to be sorted back to original Orders arrive (randomly) in totes to one of the Sortation station's inbound tote queues, and await a sortation operator. Each arriving tote will contain a number of the items to be sorted. When an operator becomes available, the tote encounters a processing delay while the items are removed one at a time, scanned, and distributed to a sortation matrix. The tote is then moved to the outbound tote queue for return to the carousel AS/RS as an empty tote. Items arriving as a Hot Pick go to the head of the tote queue, for priority processing. The sortation matrix itself, and the order pick up are not modeled.

Other Considerations

• Conveyor Bypass - The conveyor system has a bypass loop on the inbound (to AS/RS) lane just after the accumulation and bar code scan station. This allows a tote to be routed back to a workstation destination without being conveyed all the way to a carousel robot. All totes that are transferred from one station directly to another (e.g. from inspection dispatch to inspection workstation) will go through the bypass. The accumulation queue size and delay through the bypass will be of key interest in the simulation

• Empty Tote Lane - In order to dispatch empty totes quicker when required at a workstation, the system will attempt to keep a queue full of them in a special conveyor lane near the bypass loop (see drawing). Empty totes will always be dispatched from this lane if available, and if not, from a random location in the carousel AS/RS.

• Carousel AS/RS Operation - We assumed that all totes called from and returned to the carousel AS/RS will be from and to randomly assigned locations, with equal probability of being assigned to any carousel. Accurate transit time, carousel rotation delays, and robot load/unload delays must be modeled, since the utilization of the carousel/robot pairs is of key interest in the simulation.

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- Shift Schedules and Breaks - A 24 hour operation for an extended period of time was simulated. Some functions are staffed (and operate) on only a single shift, some on two shifts, and none are scheduled for the third shift. The model takes this into account. Additionally, we accounted for operator breaks (15 minutes, twice a shift, for all operators), and lunch breaks (40 minutes in the middle of each shift).

- Batch Picking versus Complete Order Picking - The order Picking process at St. Louis Park usually operates in a batch picking mode, with a certain "batching" or commonality factor.

- Bulk Areas - The Bulk Storage areas were not included in this model, as the operation in this area is essentially separate, with limited activity.

Simulation Period and Reporting

We modeled the operation of the MHS system for 19,200 minutes at a time (2 shifts/day x 8 hours x 60 minutes x 5 days x 4 weeks), or 1 month of simulated operation, to determine the following:

- The utilization of each work station and operator.

- The utilization of each carousel/robot pair.

- The utilization of the conveyor and accumulation zones.

- The queue sizes at all critical points, including the sortation area inbound queues, the bypass loop, and the inbound and outbound scanner queues.

- The total number of orders or each type (Pick, Receipt, etc.) processed during the period.

- The utilization of available "empty" totes in the system.

- The average conveyor transit time required between key stations, such as Inspection Dispatch to Inspection stations.

- The utilization of the empty tote lane, and the percentage of required empty totes dispatched from this as opposed to carousel storage.

Data and Parameter Definition

- Order Generation

    - - Pick Orders: Infinite (e.g., there is always another Pick Order waiting to be processed)

    - - Receipts: 450 per day (1 shift/day basis), generated as two batches of 225 each, one at the beginning and one late in the shift.

    - - Inspection: Infinite

- **Receipts Operation**

  Processing time per item modeled as a normally distributed random process, with average of 2 minutes and standard deviation (s.d.) of 10 second.

  There are two Receipts stations, each with one operator, working a single shift per day; each station has 3 tote positions in the inbound queue, and 3 positions in the outbound tote queue.

  Approximately 12 items on the average are stored in each new (empty) tote at the station before it is conveyed to the AS/RS. Assume 10% of the items will be stored in a specific tote in storage, which will require 2.5 minutes to be retrieved and conveyed to the station. A supply of empty totes must be kept at the station.

Inspection Operation

There are 2 inspection Dispatch stations, each with 3 tote positions inbound and outbound, and 1 operator. The dispatch dwell time is a normally distributed random time given as: 95% of the time it averages 2 minutes with a standard deviation of 10 seconds; the other 5% require an average of 7 minutes with a standard deviation of 30 seconds (these require special IPI processing, such as manual cross reference, etc.). The dispatch return dwell times are the same.

There are 10 inspection stations: 8 have two operators, and 2 have 5 operators, for a total of 26 operators. Each station has a single tote position on both inbound and outbound queues. The dwell time at an inspection station is given by the following discrete probability distribution:

Dwell Time	Probability	Cum. Probability
1 hour	.77	.77
2	.09	.86
3	.035	.895
4	.027	.922
5	.02	.942
6	.014	.956
7	.013	.969
8	.013	.982
12	.008	.990
16	.005	.995
20	.003	.998
24	.002	1.0

On return from Inspection, 90% pass and 10% fail. The inspection operation runs two shifts a day.

Stocking Operation

There are 4 stocking stations, each with 1 operator, 3 totes positions on inbound, and 3 shared outbound tote positions for each two stations. The stocking dwell time is a normally distributed random time of 4.6 minutes with a standard deviation of 20 seconds. Material transfer stocking operations require an average of 6 minutes with a standard deviation of 30 seconds.

Items are transferred to the Stocking stations manually from the Inspection Dispatch stations as they are returned from the Inspection stations (90% pass and are to be stocked; the other 10% fall and are returned to the AS/RS).

Additionally items to be stocked are created by the Material Transfer process, at the rate of 350 per day, spread evenly across two shifts.

Assume 90% of all items to be stocked are new or unique part number/lot number combinations and will be put into a new (empty) tote. On average, 12 items are stored in each new (empty) tote before it is sent to the AS/RS. The other 10% of items to be stocked require a tote to be retrieved from the AS/RS and sent.

Order Picking Operation

There are 12 picking stations, each with 1 operator and tote queues the same as the stocking stations described above. The picking operation also runs 2 shifts a day.

Picking dwell time is normally distributed random time with an average of 1.6 minutes and a standard deviation of 10 seconds. At SLP the batching factor is usually 3 (can vary from 1 to 5), 35% of all Pick Orders are Hot Picks (with only a single line item), and there can be up to 50 line items picked from a single tote. After an average of every 25 picks the sortation tote is considered filled, sent to the sortation area, and an empty tote moved into position. This requires an average of 20 seconds.

With the average batching factor included, the number of line items picked from each tote at a Picking station is given by the following probability table:

Number Picks	Probability	Cum. Probability
1	.35	.35
2	.13	.48
3	.10	.58
4	.09	.67
5	.08	.75
6	.07	.82
7	.06	.88
8	.05	.93
9	.03	.96
10	.017	.977
15	.01	.987
25	.008	.995

Sortation Operation

There are 2 sortation stations, each with 1 operator and an inbound tote queue of 6 positions. The sortation dwell time is a normally distributed random time with an average of 12 seconds and standard deviation of 2 seconds. Each arriving tote will contain an average of 25 items, with standard deviation of 5. A consolidated Order contains an average of 30 line items, with standard deviation of 10. Each time enough items have been processed to complete an Order a completion delay of 30 second is encountered.

Conveyor System

The conveyor scanner outbound and inbound queue sizes are 9 tote positions. The empty tote lane can hold 10 totes. All conveyors (both the Main and Spur1 and Spur2) run at 60 feet per minute. There is a minimum 6 foot tote separation on any conveyor. If the outbound scanner queue becomes full, all carousel retrieves must be (temporarily) halted until space is available. Likewise, if the inbound scanner queue becomes full, all tote return activity must be temporarily halted.

Carousel/Robot

Each robot has 2 tote positions in inbound and outbound queues (load/unload positions). The carousels rotate at 60 feet per minute with a 2 second ramp up delay, 2 second ramp down time, and 2 second position settling time. The robots move at 3 feet per second, and overlap their travel with the carousel rotation whenever possible. The carousels are 78 bins long. Their rotation and position delay will be a uniform probability (any point equally likely) between 6 and 84 seconds for "individual pick item" retrievals, such as Hot Picks (where no batch pick "look ahead" software can optimize the carousel rotation), and will be modeled as a uniform probability between 6 and 28 seconds for all other retrievals (batched and empty totes), which reflects the expected efficiencies from software "look ahead" in the queue of items to pick from each carousel and reordering the retrieval order.

SIMULATION RUNS AND RESULTS

Eight simulation runs have been completed, ranging from two days to five days of simulated time, and data in the form of tabular statistical results has been collected and analyzed. In each successive simulation run a small number of variables were changed as a result of analysis of the preceding run. Once the basic operation of the system was validated to perform correctly as required, successive changes were made to key system variables to "tune" the system. These changes centered around the number of operators required at workstations (to achieve required throughput with no more than 80% average utilization each), the speeds of the various conveyor spurs, tote separation on conveyors, tote queue sizes, and certain critical control algorithms. This process was used to eliminate bottlenecks and excessive queue sizes encountered in the early runs.

With the exceptions of the outbound laser scanner queue size and the sortation operator utilization, the initial simulation results showed the system to operate as desired. Several runs were required to adjust and test system parameters to correct these problems. By increasing the conveyer speeds for the two main segments (Roller and Main) and adjusting the scanner

delay, the bottleneck at the outbound scanner was eliminated.

The bottleneck at the sortation stations was examined next. Two operators are sufficient to keep up with required throughput for current (1986) operations, but further simulation runs showed that a third operator is required to meet peak demands and the projected requirement.

Peak activity with twelve active picking stations showed combined throughput in excess of projected requirements by 27% (7000 line items per day, as opposed to 5100 required). Simulation runs showed that the 5100 requirement can be met with nine to ten active stations (average).

Results for the inspection operation show that the 26 inspection operators can complete about 240 lots per day (16 hour day), with the two dispatchers busy about 70% of the time (70% utilization). However, projected requirements call for 350 lots per day, which would require an additional 10 to 12 inspectors.

The final simulation model run indicates the following simulation results:

General Observations

In order to complete required throughput for the various operations, the conveyer system is highly utilized, with average tote traffic of 1 every 12 to 14 seconds both inbound and outbound, and a bypassed tote every 40 seconds. Although this is approaching the limits of the conveyer system at the speeds designated (no more than 120 feet per minute to reduce noise levels), no bottlenecks or resulting congestion is seen. The conveyer system is capable of keeping up with demand at the various workstations, and operators spend little or no time waiting for work to arrive.

Carousel/Robot Utilization

On the average, only 18% of the carousel/robot throughput capacity is utilized. This is uniform across all ten pairs. This is partly due to the optimization algorithm for tote retrieval assumed to be used (multiple outstanding retrieval requests at any point in time allow for constant ordering to minimize the rotation to a few bins at a time). The relatively low demand on each carousel allow a single tote inbound and outbound position at each robot to be sufficient.

The addition of the empty tote lane to the conveyer system accounts for part of the low carousel cycle demand - some 60% to 70% of all requests for empty totes are satisfied with totes from the lane, the others being retrieved from a random available carousel when the lane is temporarily empty.

Conveyer System and Scanner Utilization

There are four conveyer segments defined in the system. The utilization is as follows:

- "Roller" conveyer (120 ft./min.) - 4 totes in transit on the average, 13 maximum.

- "Main " conveyer (120 ft./min.) - 2 totes average, 9 maximum.

- "Spur 1" (60 ft./min.) - 2 totes average, 9 maximum.

- "Spur 2" (60 ft./min.) - less than 1 on the average, 6 maximum.

The empty tote lane maintains an average of 2.68 totes available, and supplies 60% or more of all requests for empty totes. The bypass queue has less than one tote waiting on average, and a maximum of eight - which the drawings show there is adequate space for. Both the outbound and inbound scanner queues show low utilization, with no more than one tote waiting at any time. With the high tote throughput, both the outbound and inbound scanners are utilized close to 40% of the available time.

Workstation Utilization and Throughput

The model was designed to drive the 12 picking stations at full speed to determine the maximum throughput they could achieve. The simulation shows them busy 98% of the time or more, showing little or no wait for arriving work totes. At this utilization, they each produce an average of almost 590 line item picks per 16 hour day. At an 80% (target) utilization, the expected total throughput of 5,664 line items per 16 hour day, or 111% of required throughput for 1995 projections.

The inspection operation simulation was designed similarly, to determine the maximum throughput. Results show that with 26 inspectors the throughput is 240 per 16 hour day when they are utilized 98% of the time. Although this is sufficient for current operations, 1995 projections require 350 lots per day. At an 80% utilization of each inspector (a reasonable target), this would require close to twice the current number of inspectors. Since the dwell time is so long for the inspection operation (1 to 16 hours), no additional tote delivery stations would be required for this. The two dispatch operators are utilized only 60% each in order to keep the 26 inspectors busy.

In order to complete the required number of received items, the two receiving stations were utilized only 50%.

In order to complete the required throughput at the four stocking stations (material transfers plus complete inspected/certified lots), these stations were utilized between 76% and 85% of the time, and process 560 lots total in a 16 hour day.

Sortation Area Utilization

In order to keep up with the picking operation (running 12 operators at full speed), three sortation operators are necessary and kept busy about 60% of the time. With only two

operators, they cannot quite meet demand, and their tote queue continue to slowly grow. With three operators, the tote queues have less than two totes waiting on the average and no more than ten maximum.

RECOMMENDED CONFIGURATION CHANGES

Since the final simulation results do not indicate any serious problems with congestion or bottlenecks in the material handling system configuration, the only serious design changes recommended, as reviewed above, are: 1) Operate the Roller and Main conveyers at 120 feet per minute; and 2) Add a third sortation accumulation lane, workstation, and operator. Also, since the utilization of operators is high (except when no work is waiting) and there are few delays in obtaining work (even with the high tote traffic), we see no reason to change the design of the workstations or the length of their tote queues.

The tote conveyer system, with the bypass loop and empty tote lane, is highly utilized but shown by the simulation to be effective in handling the traffic with few queue delays.

The utilization and throughput of all workstations is within design objectives with the exception of the inspection stations. It should be noted that the throughput of the inspection operation (lots inspected per day or week) is primarily dictated by the inspection dwell times. Simulation results suggest that the additional throughput required for the projected 1995 requirements could be handled by adding more inspectors sharing the existing tote delivery stations.

Analysis of the combined throughput of the picking stations suggests that fewer than the twelve active stations will be needed, even to meet projected 1995 requirements. Potential savings by eliminating some of these stations from the system would be relatively small, and the operational flexibility gained by having these stations available suggest no design changes.

The relatively low utilization of the ten carousel/robot pairs capacity indicates that there would be some opportunity to reduce equipment costs by using robots that service two carousels each instead of one each. Physical plant constraints and storage volume requirements make it impractical to consider using fewer but larger carousels. By reducing the ten robots to five double service units, a saving of $100,000 should be possible. We estimate that the utilization of the double wide robots would be less than 50%, which would not significantly reduce the system's ability to handle peak throughput demands.

The suggested addition of a third sortation tote lane and station will require changes in the sortation scheme and equipment. The original plan for two colored lights above each sortation matrix cell would be too complicated. Instead, it is suggested to identify the target cell with a numerical display at each sortation operator's station, and require validation of the correct cell by a positive response from the operator using a bar code scanner.

CONCLUSIONS

The simulation results have been interpreted and the indicated changes in the system layout, operator assignments, and operating procedures have been made. The current plan for the MHS system operation at the St. Louis Park facility has incorporated these changes. The simulation showed several potential problems that would not have been discovered otherwise.

APPENDIX B

STORAGE, HANDLING, AND CONTROL SYSTEM
SPECIFICATION

TABLE OF CONTENTS

SECTION 1.0

SCOPE OF WORK AND BID REQUIREMENTS

TABLE OF CONTENTS

1.0   SCOPE OF WORK & BID REQUIREMENTS

1.1   Scope of Specification

1.1.1   This specification describes the material handling and
          control system requirements for the Honeywell Avionics
          Division Material Handling System (MHS) Automation
          Project. The equipment specified in this document will
          be installed in the existing Avionics Division facilities
          in St. Louis Park, Minnesota. The system is designed to
          handle the storage, retrieval, and material movement
          functions for the receiving, receiving inspection, and
          stock room areas of the existing operation.

1.1.2   The automated material handling and control system is made
          up of the following major sub-systems:

          AS/RS System

          o   Carousel AS/RS (Nine Units)
          o   Robot Inserter/Extractor System
          o   Vertical Carousel System for
              Inspection Folders

          Conveyor System

          o   Tote Conveyor Interconnect System
          o   Work Station Delivery System
          o   Sortat on Matrix

          Computer Control System

          o   Transaction Processing Subsystem
          o   Database Subsystem
          o   Equipment Monitoring and Control Subsystem
          o   Workstation I/O Device Subsystem
          o   Data Link Subsystem

          In addition to these systems to be provided by the material
          handling systems contractor, the Avionics Division will
          utilize conventional pallet and bulk material storage
          systems and some manually accessed small parts storage
          that will be controlled by the MHS Control System.

1.1.3   The selected supplier must quote the computer hardware
          and software for the MHS Process Control Computer System,
          but Honeywell reserves the option to provide the computer
          equipment in the actual system implementation. Proposals
          using Honeywell computer equipment will be favored, since
          Honeywell currently uses an integrated system of
          Honeywell DPS-6 and DPS-8 computer equipment at

this site. Further information on the computer hardware options is included in Section 5.1.2 of this specification.

The supplier must use the selected system hardware or make other provisions to provide a developmental system for use in internal software development in his facility prior to installing the software at the Honeywell installation site. The control system must be designed for on line interfacing with the existing DPS-8 based HMS business software system currently being installed in the Avionics Division.

1.1.4   Honeywell intends to award the contract for the automated material handling and control system to one prime contractor, but reserves the right to make a partial award if necessary.

1.1.5   The system is to be installed in the Honeywell Avionics Division facilities as shown in Honeywell Drawing MHS-1 Revision A.

1.1.6   Honeywell will clear the installation area in the building, including re-routing of overhead utilities in order to provide adequate space for the installation. Honeywell will provide access for the supplier to unload materials through the truck receiving docks in the building and allow movement through the existing building aisles.

1.1.7   Since the system will be installed in an existing operating facility, installation phasing will be required in order to assure that the current manufacturing support levels are maintained during the entire installation, checkout and startup period. Honeywell will clear the room for instal-lation of the carousels, robots and input/output conveyor systems first, followed within two weeks by clearing of the area for the picking, stocking and receiving operations. The areas for the remainder of the conveyor system, including Incoming Inspection and Consolidation will not be available for installation until the remainder of the system has been accepted and loaded.

1.1.8   Potential system suppliers are encouraged to quote alternative concepts and equipment which may meet Honeywell requirements at a lower cost, increase capacity, improve reliability, or provide other benefits. However, the requirements of this specification must be met in the basic proposal. Any alternatives must be specifically identified as such, and corresponding savings and costs itemized.

1.2 General Conditions of Contract

    1.2.1   Honeywell representatives will work only through the prime contractor on all changes of scope in subcontracted work.

    1.2.2   The system installation must be in compliance with all applicable federal, state, and local laws, rules, regulations and orders in effect when the order is placed.

    1.2.3   The mechanical and electrical equipment and installation must comply with all provisions of:

        o Department of Defense Standard # 1685 -Electrostatic Discharge Control Program
        o National Electrical Code (latest edition)
        o State and Local Electrical Codes o Occupational Safety and Health Act
        o Applicable Environmental and Pollution Control Regulations
        o American Welding Society for Welding
        o Industrial Risk Insurers (IRI) for Fire Protection
        o National Electrical Manufacturers Association Standards for Electric Motors, controls and enclosures.
        o National, State, County and Municipal Structural, Safety and Building Codes

    1.2.4   The system contractor must abide by Honeywell's established security and sign-in procedures. Building access will be provided on a first and second shift basis.

    1.2.5   During construction on the Honeywell site, all contractor work must be performed in such a way that there is no interference with Honeywell's ability to perform normal manufacturing operations.

    1.2.6   The system contractor shall be responsible for obtaining all necessary test or installation inspection approvals from appropriate governmental agencies.

    1.2.7   Honeywell will conduct continuous inspections of the system components during fabrication and installation and perform acceptance tests in accordance with the requirements specified in Section 1.8 of this document.

    1.2.8   The system contractor shall be directly responsible for all work and materials installed or supplied by his

subcontractors, and all equipment supplied to him by other manufacturers within the scope of work. The contractor must identify to Honeywell all subcontractors he employs and must have total responsibility for obtaining, directing, scheduling, and controlling them in the process of satisfactorily completing the contractual scope of work. This list must include the company names, addresses, telephone numbers, and the prime contractor's contact at that company.

1.2.9   The selected vendor shall supply to Honeywell a certificate of insurance detailing the type and amount of insurance that will cover their company during the performance of the contract. Should subcontractors be utilized in the performance of any part of the contract, providing insurance coverage to all subcontractors shall be a responsibility of either the prime contractor or the subcontractors themselves and is not the responsibility of Honeywell.

1.2.10   The entire contracted material handling and control system shall be covered by a warranty with a period of no less than 12 months. The prime contractor must provide this coverage, regardless of warranty provisions provided by individual subcontractors or component suppliers. The system warranty will not start until the system has been accepted for production use by Honeywell.

1.2.11   Installation timeliness is a major concern, since the new system is needed as quickly as possible in order to support Honeywell's manufacturing operations. The selected system supplier must commit to a fixed schedule and meet specified installation milestones in order to meet these requirements. Frequent review meetings will be held in order to verify progress toward scheduled milestones.

1.3 Project Quote Requirements

1.3.1   All potential system contractors must submit complete technical proposals describing the configuration, features, and capabilities of the hardware and software proposed. Three copies of the proposal must be provided. As a minimum the technical proposals must include the following:

o Equipment technical descriptions
o Plan and elevation drawings
o Description of safety features
o Software detailed description

- o   Preliminary software structure charts
- o   Maintenance requirements
- o   Description of documentation
- o   Description of training plan
- o   Honeywell facility requirements
- o   Floor loading requirements
- o   Equipment utility requirements
- o   Preliminary spare parts list
- o   Requirements for any additional equipment that is necessary for proper operation

1.3.2   System contractor proposals must include a separate section that provides a detailed fixed price quotation that will remain firm for a period of 180 days from the proposal date.   A price breakdown of the major system components must be provided as follows:

CAROUSEL SYSTEM

- o   Carousel Equipment
- o   Carousel Controls
- o   Carousel Electrical Installation
- o   Carousel Mechanical Installation

ROBOT SYSTEM

- o   Robot Equipment
- o   Robot Controls
- o   Robot Electrical Installation
- o   Robot Mechanical Installation

CONVEYOR SYSTEMS

- o   Conveyor System - Mechanical Equipment
- o   Conveyor System - Electrical Equipment
- o   Work Stations
- o   Work Stations Installation
- o   Conveyor System - Installation

CONTROL SYSTEM

- o   Control System Hardware
- o   Control System Design
- o   Control System Software
- o   Control System Installation
- o   HMS System Interface

PROJECT COSTS

- o   Project Management
- o   Site Supervision
- o   Recommended Spare Parts
- o   Freight

1.3.3   System contractor proposals must include a fixed project schedule with at least the following major milestones:
- o Contract Award
- o Completion of System Functional Design Document
- o Completion of System Detailed Design Document
- o Completion of Installation Drawings
- o Procurement of System Components
- o Fabrication of System Components
- o Component Delivery Schedule
- o Supplier Software Demonstration
- o On Site System Installation
- o Local Controls Demonstration
- o System Available for Throughput Test
- o Throughput Test
- o Operator Training
- o Maintenance Training
- o System Reliability Test
- o System Acceptance

1.3.4   Suppliers should quote the shortest system installation times that are possible without incurring excessive additional costs. Honeywell desires to have the total system operational within approximately 12 - 15 months or less after placement of the order. Suppliers should also specify what schedule improvements would be possible at additional cost and what the related cost increment would be.

1.3.5   Suppliers must provide with their quotation a separate list of any exceptions they have taken to the Honeywell specification. This consolidated exceptions list must refer to specific specification paragraph numbers, state the exception and the reason for the exception, indicate any related cost differences, and recommend alternative provisions for achieving the specification intent.

1.3.6   This specification defines the minimum requirements for each equipment section. Suppliers are encouraged to quote equipment that exceeds these requirements. Compliance with the specification requirements does not relieve the system con-tractor of his responsibility to provide equipment that effectively and efficiently performs the intended functions defined by Honeywell.

1.3.7   Suppliers are encouraged to provide with their proposal a complete set of company background information, including product brochures, lists of

similar system installations, and recommendation of specific system installations that could be visited by Honeywell personnel as part of the supplier selection process.

1.4 Training

1.4.1   The system supplier shall be responsible for the on site training of at least six Honeywell system operators and four stockroom supervisors in safe and efficient operation of the material handling and control system.

1.4.2   The supplier shall conduct an on site training course for at least six Honeywell equipment maintenance personnel. The training course must include at least the following:

o Mechanical System
o Electrical System
o Control System
o Preventive Maintenance Procedures
o Trouble Shooting Techniques
o Microprocessor Diagnostics
o Safety Precautions

1.4.3   Software support training shall also be provided as part of the contractor's scope of work. This training must include sufficient instruction to allow Honeywell systems analysts and programmers to diagnose software problems, make minor changes in the system that may be required after expiration of the one year software warranty, and plan for future system enhancements.

1.4.4   "On the job" training for Honeywell equipment maintenance and systems personnel shall be provided by the system contractor. This training will include observation and participation in the development of software modules, control system software module integration, and system checkout and testing at the Honeywell facility.

1.5 System Documentation

1.5.1   Detailed system installation drawings must be provided to Honeywell for review and approval within three months after contract award and prior to contractor procurement of system components or component fabrication. One reproducible set plus three copies are required.

1.5.2   Prior to final system acceptance, "as built" drawings must be provided to Honeywell. Honeywell will allow deviations that they consider to be minor to be noted on the installation drawings along with explanatory notes. Any major changes from the original installation drawings must be redrawn in order to provide adequate "as built" drawings. One reproducible set plus three copies are required.

1.5.3   A System Functional Design Document must be submitted to Honeywell for approval within the first four months after contract award. The document must include at least the following detail:

   o Application Software Functional Design Specifications (including description of the Query capabilities for generation of reports)
   o Database Structures and Record Layouts
   o CRT Screen Formats
   o Report Formats
   o Process Control Computer/HMS Interface Specifications
   o Preliminary Backup/Recovery Procedures
   o Recommended Contingency / Disaster Procedures
   o System Security Features
   o Program Coding Standards
   o Detailed Computer Hardware List
   o Application Software Detailed Design Completion Schedule

1.5.4   A System Detailed Design Document must be submitted to Honeywell for approval prior to starting software construction. The document must include any revisions to the approved System Functional Design Document, in addition to at least the following detail:

   o System Software Structure Charts
   o System Performance Capabilities
   o Preliminary System Application Software Design Documentation
   o Preliminary System and Application Software Diagnostic Procedures Manual
   o Application Software Construction/Implementation Schedule

1.5.5   The contractor must provide Equipment Maintenance Manuals that include at least the following:

          o Electrical Maintenance Procedures
          o Mechanical Maintenance Procedures
          o Complete Mechanical Component Drawings
          o Complete Electrical Schematic Drawings
          o Spare Parts List
          o Preventive Maintenance Schedules
          o Trouble Shooting Procedures
          o Microprocessor Diagnostic Procedures

1.5.6   Three copies of all system documentation must be provided.

1.5.7   In conjunction with beneficial occupancy and before final payment, detailed documentation of the final system software design, including the final System Design Document and a copy of all system application software and source code must be provided to Honeywell.

1.5.8   All documentation must be revised and updated with any revisions or part substitutions that are required during the warranty period. These revisions must be submitted to Honeywell within 30 days after the change has been implemented and proven to be successful in correcting the problem.

1.5.9   During the warranty period the supplier must provide on-site field service and telephone consultation for equipment and software problems encountered by Honeywell. When the system is not capable of accessing all totes and moving them on the conveyor system under computer control, the supplier must provide emergency service. Under these conditions, telephone consultation must be provided within one hour and on-site service within 8 hours from the time of request by Honeywell. If the problems are determined to have been caused by warranty-covered items, there must be no charge to Honeywell for this service.

1.6 Project Management

1.6.1   The entire contractor's scope of work on this project must be managed by an experienced project manager, who will serve as the primary interface between Honeywell and the contractor. The project manager must have the responsibility and authority to competently manage the entire project from the date of the contract award to the final acceptance by Honeywell.

1.6.2   The contractor must also provide a full time installation supervisor during all periods of time when work is being performed on the Honeywell

site. On site installation work will not be allowed
unless there is a competent installation supervisor
present.

1.7 Facility Conditions

1.7.1   Honeywell facility environmental conditions will be as
                    follows:

                    TEMPERATURE

                    o In AS/RS Area = 72 degrees plus or minus 20 degrees.
                    o Outside AS/RS Area = 72 degrees plus or minus 25
                       degrees.
                    o Computer Room = 70 degrees plus or minus 5 degrees.

                    HUMIDTY

                    o Humidity Control in the Computer Room Only = 45 percent
                       plus or minus 5 percent.

1.7.2   Honeywell will provide an enclosed computer room with
                    raised floor, filtered power supply, and the necessary
                    environmental controls.

1.7.3   Honeywell will supply 480 volt, 3 phase, 60 hertz power
                    to a fused disconnect box located on the wall at the
                    rear of the Carousel AS/RS Area and to the motor control
                    center location shown on Honeywell Drawing # MHS-1. All
                    additional power distribution must be supplied from these
                    sources. If additional power is required, the exact
                    requirements must be stated in the supplier's
                    proposal.

1.7.4   The floor in the installation area is of typical
                    warehouse condition with a steel trowel finish. The
                    concrete is 6" thick with WWF reinforcing with joint
                    controls approximately on the building grid lines.

1.7.5   During the installation period, Honeywell will supply
                    temporary 110-120 volt power to a central location in the
                    installation area. The installation areas are within
                    existing buildings, and the installation areas will be
                    cleared prior to the arrival of the contractor's
                    installation crew.

1.7.6   Honeywell will provide in plant compressed air to a
                    central location in the installation area. However,
                    from the plant source to the point of use it shall be the
                    responsibility of the supplier to install all necessary

piping, filters, lubricators, dryers and controls that are required for the supplier's equipment.

1.7.7   All ceiling hung or roof supported equipment must be approved by Honeywell. The supplier shall furnish approximate weight of the equipment and confirm with Honeywell that support trusses are of adequatedesign prior to installation. The equipment supplier must design, furnish, and install all hangers and cross bracings as required by the static and dynamic loading of the equipment.

1.8 Inspections and Acceptance Testing

1.8.1   A series of inspections and acceptance tests will be required in order to adequately monitor the system development and installation. Inspections will be required periodically at the supplier's manufacturing facilities during the manufacturing of the system components, during the integration and testing of system software, and at the Honeywell Avionics Division facilities. Formal inspections and tests are as follows:

o   Carousel Inspection Prior to Shipment - At least one of the carousels must be inspected by Honeywell and approved for shipment to the installation site prior to the shipment of any of the carousels to the site.

o   Supplier Software Demonstration - Prior to shipment of the control system hardware or software ,to the Honeywell site, the control system must be demonstrated to Honeywell personnel at the supplier's site, and Honeywell must approve the system for shipment. The control system demonstration must include all system commands, displays, reports, and responses to anomaly conditions, using simulators for carousels, robots, conveyors, and other devices. Any changes in the system software that are necessary to comply with this specification must be incorporated prior to approval by Honeywell.

o   Carousel/Robot Local Control Test - Once the Carousel system has been satisfactorily installed, the supplier must perform a demonstration of the carousel and robot

operation under local control. This demonstration must include at least the following:

- Each carousel and robot must demonstrate the capability to perform all required functions under local microprocessor keyboard control.

- Each carousel and robot must demonstrate the capability to perform the required dual command cycles within the specified cycle times.

- All system safety devices must be demonstrated and shown to operate properly.

- Each carousel and robot must demonstrate the capability to accurately position horizontally and vertically.

- Each carousel and robot must demonstrate the capability to operate successfully with maximum load weight and with a variety of loaded and unloaded tote conditions.

All portions of the Carousel system must meet these requirements prior to further acceptance testing.

o System Test - The complete system testing will be accomplished once the supplier has installed and checked out all system elements. In this testing the supplier must demonstrate full system operation under computer control. All specified system functions, features, and safety devices must be demonstrated.

o Throughput Test - The supplier must demonstrate the capability of the entire system to meet the specified average throughput rates for a period of at least four consecutive hours of operation. Honeywell will supply operating support personnel and test loads for the test. Upon completion of the demonstration at average throughput rates, the supplier must conduct a one-hour demonstration of operation at peak throughput rates.

o   Duty and Reliability Test - A ten-day testof system
    reliability will be conducted by Honeywell,   using
    Honeywell operating   and maintenance   personnel,
    (Supplier's main-tenance personnel may observe and
    assist.) Honeywell   will   maintain   a   iog   of   all
    system downtime and maintenance activities during
    the   Duty   and   Reliability   Test.   During this
    period   the system must demonstrate the capability to
    operate on a two-shift per day basis with at   least
    98 percent uptime. Failure of any part of the test
    will   require   repetition   after   corrective   work   has
    been performed.

SECTION 2.0

SYSTEM OPERATING DESCRIPTION

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2.0 SYSTEM OPERATING DESCRIPTION

2.1 Introduction

The Honeywell Avionics Division Material Handling System (MHS) Automation Project was initiated to design, procure, and install new, state of the art automated systems for the storage, retrieval, and handling of material for the receiving, inspection, and stock room areas of the St. Louis Park plant.

This system is intended to be a dedicated, real time material handling and control system. It's purpose is to directly control the handling and storage of material prior to the assembly process. It is to augment, not replace, the existing and scheduling systems at Honeywell. The mainframe computer which runs the material requirements planning (MRP) and scheduling systems that drive the MHS will be supplied by Honeywell, and is referred to as HMS. MHS and HMS will communicate via an on-line, hard wired communication link summarized elsewhere in this document.

The current operations at both facilities are a combination of manual handling, shelf storage, and batch oriented data processing support. These functions at the St. Louis Park (SLP) operation that will be directly affected by the implementation of the MHS are:

DIAGRAM 2.0
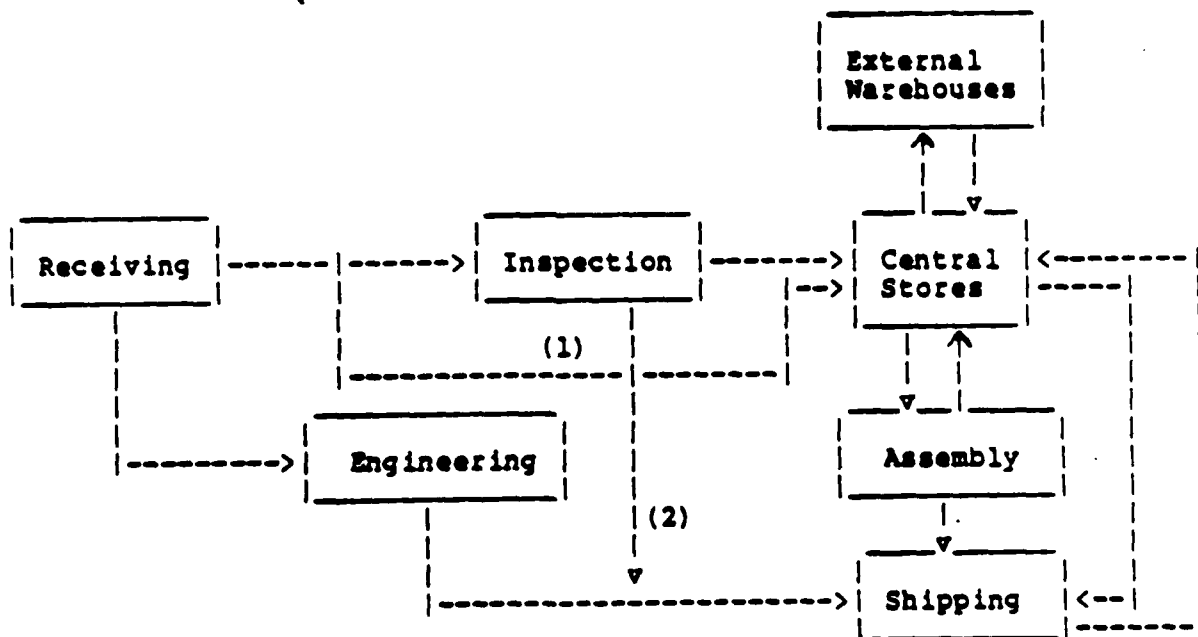
Notes: 1: This path is for non-certified material only.
        2: This path is for rejected items being returned.

The directed arrows indicate the only allowable logical material transitions. The functional blocks of the above diagram that will be directly controlled by MHS will be Inspection and Central Stores. MHS will not track or maintain information on any item until it exits the Receiving function (logically, or afater it leaves Central Stores (physically) for Assembly or Shipping.

The primary functional requirements of MHS for material flow can be summarized as follows:

DIAGRAM 2.1

MHS MAJOR FUNCTIONS AND MATERIAL FLOW

```
Outside                          MHS                      MHS   AS/RS
Environment                      Function                 System

Receiving ---------> 1: Receiving Put-away --|-------->  Un-inspected
Dock                                         |           Material
                            (6) <-----|  |---- (Un-certified)
                                         |
Inspection <-------- 2: Inspection Station <----|
Stations             Dispatch          <----------      IPI Folder
     |                                        |-->        Storage
     |                                        |
     |----------------> 3: Inspection Dispatch     |
                           Return:        -------|
                           4: Rejected Mtrl. ----------->  Non-conformance
                           5: Accepted Mtrl. ---|          Material
                                                 |
          |----------------------------------|
          |
          |---> 6: Detrash & ----------------->  Certified &
          |---> Stocking                         Receipted
          |                                      Material
          |
          |---- 7: Issue Non-conformance <----- Non-conformance
Return or <--------- 8:   Material                 Material
Scrap
                                               Certified &
          |--- 9: Issue Certified <----------   Receipted
          |       Material (Pick)               Material
          |
          |---> 10: Consolidation
                    (Order Sortation)
                          |
Assembly  <---------------------|
Operations

Material -- ----------> 11: Restock  12: -------------->  Un-inspected
Transfers               Material 13:--|                   Material
(Other Receipts)                      |
                                      |------------->  Certified &
                                                       Receipted
                                                       Material
```

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2.2 Major System Elements

There are three major system elements in the MHS system, as defined below. The remainder of this section will describe the primary system functions to be performed by the MHS system. More detailed operating and transaction descriptions can be found in section 5.

2.2.1 AS/RS System

   o Carousel Storage System - Material
   o Robot Inserter/Extractor System
   o Carousel Storage System - Inspection Folders
      (Details in section 3.0)

2.2.2 Conveyor System

   o Tote Conveyor Interconnect System
   o Work Station Delivery System
   o Sortation Matrix
      (Details in section 4.0)

2.2.3 Computer Control System

   o Transaction Processing Subsystem
   o Database Subsystem
   o Equipment Monitoring & Control Subsystem
   o Workstation I/O Device Subsystem
   o Data Link Subsystem
      (Details in section 5.0)

2.3 Receiving Functions

Material arriving at the receiving dock is identified to the Honeywell HMS system via a CRT in the receiving area on-line to HMS (not part of the MHS system). Upon successful completion of the receiving process, a bar code label is generated (by the HMS system) with the Part Number and Lot Number (denoted as In-Ship number), and attached to the material packing container. The material is then transferred or conveyed by manual means to a MHS station designated as a Receipts or Receiving Put-away station (step 1 in Diagram 2.1).

HMS generates an expected receipts record for the material, and sends this down the link to the MHS. All items received through HMS, whether inspectable or uninspectable, will generate an In-Ship record for MHS.

The operator at the MHS Receipts station removes new (incoming) material from the container arriving from the receiving area and wands the bar code In-Ship label on the packing box. MHS matches this to the matching In-Ship record downloaded from the HMS system previously. Note that if no In-Ship record exists for the item, it cannot be

Receipted into the MHS system, as no manual key data entry for the
in-Ship data is provided for at this operation step.

If the material is inspectable (requires inspection prior to issue),
it is placed into an MHS storage tote (in its original packing
container) and conveyed to the MHS AS/RS for storage prior to
inspection.

If the material is uninspectable (requires no inspection prior to issue),
it is placed into an MHS storage tote (in its original packing
container), and placed onto the return conveyor. The material will then
be queued in the AS/RS for stocking or conveyed directly to an MHS
station designated as a Stocking station (step 6 on Diagram 2.1).

2.4 Material Inspection Functions

The inspection operation is initiated by the MHS inspection dispatcher.
The dispatcher requests a list of all material received and awaiting
inspection, which is displayed on the MHS inspection dispatch terminal
in "date needed" order. A decision is made by the dispatcher (with the
aid of Honeywell's HMS CRP system, which has a separate terminal at
this location) which material to release for inspection, and which
inspection workstation to send it to. This information is manually
entered into the MHS terminal by the inspection dispatcher. MHS then
routes the tote containing that material to the inspection
dispatch station from carousel storage. When the tote arrives there,
the dispatcher wands the bar coded tote I.D. MHS instructs the
dispatcher which item to remove from the tote, and requires a bar code
scan to verify. The delivery tote (which usually contains other
items) is then returned to carousel storage. If the tote is empty,
the operator verifies that it is empty and returns it for storage.

Each item to be inspected has an Inspection Procedure Information (IPI)
folder on file in a separate (vertical carousel) AS/RS, which is
physically located adjacent to the inspection dispatcher's station.
MHS sequences the IPI AS/RS to the proper bin for the matching IPI
folder. The dispatcher picks the IPI folder, wands the permanent bar
code label on the folder for verification, and places the folder with
the matching material to be inspected in the tote. The tote is then
automatically dispatched to the inspection station via the workstation
dispatch conveyor.

MHS does not track the material during the time that it resides at an
inspection workstation(s).

When the inspection process is completed, the material is returned to the
inspection dispatch station in a delivery tote, via the inspection
dispatch conveyor. The IPI folder is removed, scanned, and returned to

IPI vertical carousel storage. The dispatcher updates the Inspection status of the material via the MHS terminal. Material that has been accepted is then placed in a storage tote and manually transferred to a storage rack (flow rack) adjacent to the Stocking workstations, where it awaits an available operator to perform the Stocking operation.

Material that has been rejected or is of questionable status will be returned to the AS/RS to be queued for disposition or removed from the system for scrapped or returned to the vendor. Unaccepted material that is returned to the AS/RS will be un-available for Stocking or Picking functions until Incoming Inspection has determined that it is acceptable and changed the Inspection status.

2.5 Material Storage Functions

When material arrives at a Stocking workstation, the operator enters the material storage requirement code to MHS. If the inspection status record does not indicate acceptance for this item, it cannot be stored. The reason for this discrepency must be determined and corrected prior to actual storage of the material.

The operator unpacks, detrashes, counts, and bags the material and the MHS will select the appropriate storage tote via the storage algorithm and route that tote to the station or tell the operator to select an empty tote for storage. The operator is prompted for required information to complete a data record for the material. MHS then prints a bar code label for the part. The operator then attaches the bar code label to the bag or other storage subcontainer, wands the label, and then wands the tote I.D. MHS instructs the operator which cell location within the tote to store the bagged and labeled material. The operator then wands the task complete bar code on a menu attached next to the reader and moves the tote to the return conveyor input, where it is automatically returned and stored in the MHS carousel AS/RS.

Material that is designated for the Automatic Insertion (AI) area will automatically be stored in carousel number 6 so that the robot at the rear of the carousel can access totes containing these parts. Other material may also be stored in carousel number 6, but the system will not store non-AI material in this carousel until the other carousels are full.

2.6 Order Picking Functions

The Storeroom supervisor calls up a list of all pending orders (previously downloaded from HMS) on the storeroom supervisor terminal. The Supervisor can release for picking each order in a batch mode with other selected orders, release the order for individual picking, put on hold, or delete each order. MHS will not allow a part to be released for picking unless its inspection status tag is correct (e.g., CERTIFIED, or uninspectable).

Once orders are released for picking, MHS adds them to activity queues. Totes with appropriate parts are retrieved and routed to picking stations based on station activity. At a picking station, the operator

Initially logs on the CRT and activates the station. As totes arrive at the station, the operator wands the bar code I.D. of the tote. MHS then sequences the operator through the pick(s) from that tote via a series of CRT transactions. Each part is removed, counted, bagged and labeled with a bar code label printed at the station. If batch picking is active, the operator will be instructed to repeat the process as necessary so that all picks for parts from each tote for the batch are completed before the tote is returned. Exception conditions, such as insufficient parts to complete a pick, must be handled via MHS CRT transactions. Upon completion of each pick, the bagged and labeled part is placed in a "sortation bound" tote. Multiple picks for multiple orders will be placed in the same sortation tote.

When the sortation tote is filled, it is moved to an outbound conveyor position, and is routed to the sortation area. As each pick is completed, if the expected remaining quantity is less than a predetermined number, the operator will be asked to verify the count.

If there is insufficient quantity for a pick instruction, the operator will be instructed (after count verification and correction) to continue picking from another location within the tote, or from another tote routed to the station, as required.

Any of the stations may be designated as cycle count stations, stocking stations, or picking stations. Cycle counting of designated parts is performed in a similar manner as above, based on cycle counting requests downloaded from the HMS.

Picking for the automatic Insertion Area may be automatically scheduled for designated AI kits, or individual totes may be requested by part number or Tote I.D. The totes will be automatically delivered to the AI picking spur through the robot at the rear of carousel number 6. The operators will generally pick reels of components and indicate through their picking transaction the quantity of parts actually removed from storage. When remaining components are returned to storage from the AI area, the operator will enter the stocking transaction information and the system will deliver the appropriate tote. Then, the operator will place the parts in the tote, enter the quantity information, and place the tote on the lower level tote return conveyor for automatic storage.

The "hot pick" supervisor may receive a request for a part via a message from the HMS system or via a local (phone or document) request. The pick request is entered to MHS through a CRT trans-action at the supervisor's station. If no HMS generated "hot pick" request exists, it will be necessary for the supervisor to verify the order number and assembly number utilizing the HMS valid order file. Part availability can also be checked on the MHS prior to logging a pick request. All hot picks are directed to a pick station designated for this purpose only. Picks here are performed in the same manner as described above. When each pick is completed, the bagged parts are placed in an empty sortation tote with a special "hot pick" color coded card which is readily visible. The tote is then routed immediately on the conveyor system to the hot pick lane in the sortation area. All hot pick transaction records will be passed to HMS for updating of the system records.

2.7 Material Consolidation

As totes arrive at the sortation station, the operators will remove the bagged and labeled parts and wand the bar code labels on the bags. The MHS will assign a sortation matrix location to each order to he sorted. A label will be printed and attached to the matrix position, and an empty tote placed in each position. As each part label is scanned, MHS will light up the indicator light at the appropriate sortation matrix position. Since there will be two operators in this area, two colors of indicator lights will be required. All transactions scanned by a given laser scanner will only light one of the colored lights at the consolidation tote location. For each scanning transaction, the operator will place the bag of parts in the appropriate tote and push the button at that location to indicate the transaction is complete.

When each order is completed (last part sorted to matrix), the MHS will flash the lights at that location to tell the operator to push the tote back in the matrix position and will print a complete parts listing to go with the order. The operator will push the flashing buttons to indicate that the tote has been pushed back and the sortation matrix position will then be released for the next order. The completed order tote will be manually removed from the back side of the shelving and placed on a cart for movement to its use location.

Consolidation operators are instructed to be alert for the arrival of totes with "hot pick" cards, and to immediately process these.

2.8 Material Restocking

There are several transactions necessary to process Material Transfers - material that is being transferred to MHS from other Honeywell warehouses, being returned from the fabrication process to store as a sub-assembly (FAB/FAC material), vendor or source inspected material, and other transfers. Material for restocking via this path (step 11 on Diagram 2.1) may be marked as Certified, Un-Inspected, or not requiring inspection.

Most material being restocked will not have an HMS In-Ship data record available. This material will require data to be manually keyed in during the transaction. Only certain data fields will be required for this transaction. Specific edit routines will also apply, the normal type being checks for numerics, range, fields, etc.

2.9 Other System Functions

2.9.1 Bulk Material Storage

Some material will not be "totable" - too large or heavy to be stored in the carousel AS/RS. This material will be stored in standard rack storage in a separate area, designated as Bulk Storage. All bulk storage material will be processed with transactions similar to those described above, except that no

automatic transfer of material will occur. In general, once the material is initially placed in a rack location (transaction step 1), it is not moved again until issued.

There will be "remote" MHS CRT stations in each bulk material storage area, each capable of performing all function transactions (Receipt, Inspection dispatch, Stocking, Picking, Restock). The parts listing printed upon pick order completion in the small parts consolidation area will include a listing of all bulk parts required to complete each order.

2.9.2 IPI Folder Tracking

The Inspection Procedure Information (IPI) folders will be stored in dedicated locations in a separate Vertical Carousel, located adjacent to the inspection Dispatch operator station. A MHS terminal located there will provide the following on-line general file check-out and tracking capabilities, as an integrated part of the MHS software:

- o Automatic rotation to correct shelf level, and "light bar" identification of the general storage area for each file.
- o Automatic check out and check in functions as part of the material Inspection dispatch function.
- o Manual (keyboard entry) check out (retrieval) and check in of folders, using bar code reader.
- o Folder location query capability.

SECTION 3.0

CAROUSEL/ROBOT AS/RS SPECIFICATION

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3.0 CAROUSEL ROBOT AS/RS SPECIFICATION

3.1 General Requirements

3.1.1   Nine carousel automated storage and retrieval systems are planned for installation at the Honeywell Avionics Division facility in St. Louis Park, Minnesota. The systems are to be installed in the existing Honeywell facilities as shown in Honeywell Drawing MHS-1 (Rev. A).

3.1.2   The system supplier is to provide and install all system elements that are necessary to meet the requirements of this specification and to provide an efficient and reliable system operation.

3.1.3   The system supplier is to provide the necessary Project Management and Site Supervision to install and make operational the total integrated material handling and control system for the Honeywell Avionics Division as specified in this document. The carousel/robotic AS/RS must be integrated with the other system elements to form a totally functional system.

3.2 Carousel System Configuration

3.2.1   The standard handling unit for the carousels and the robots will be a Lewis ASD (or equivalent) polypropylene conductive tote 20" wide x 24" long x 4, 7, and 10" high with a maximum weight capacity of 50 pounds. The 10" tote height will have the capability to handle loads up to 12" in height. The totes will be provided by Honeywell and are not part of the proposal requirements.

3.2.2   The Carousel AS/RS is made up of the following major system elements:

o   Carousel Storage/Retrieval Machines
o   Supporting Structure o Storage Bins
o   Adjustable Wire Shelves
o   Top and Bottom Guide Rails
o   Microprocessor Controls
o   Control Enclosures
o   Other Mechanical & Electrical Support Items

3.2.3   Eight of the nine carousels (excepting carousel #6) have the following configuration:

- o # Carousels   8
- o Clear Height Available   10' 10"
- o Approximate System Height   10'
- o Carousel Bin Height (approx.)   9' 3"
- o # Carriers per Carousel   74
- o Total # Carriers (Bins)   592
- o Carousel Bin Size (approx.) 21.5"W x 22"D
      (for 20"W x 24" L totes)
- o # Shelves per Carrier   16
- o # Shelves per Carousel   1184
- o Total of Shelves   9472
- o Tiers for 4" High Totes   10
- c Tiers for 7" High Totes   5
- o Tiers for 10" High Totes   1
      (for 12" high loads maximum)
- o Total Tote Storage Locations   9472
- o Maximum Weight Per Carrier   800#
- o Weight Capacity Per Shelf   50#
- o Overall System Length.   75'
- o Overall System Width   60'
- o Carousel Travel Speed   80 ft/min

The carousel system configuration is shown in Honeywell Drawing MHS-1.

3.2.4   In order to allow potential suppliers to use their standard equipment and system configurations, the exact system configuration may vary within the following limits:

- o Minimum Storage Capacity   9344 Totes
- o Overall System Maximum Height   10' 10"
- o Overall System Length   79'
- o Overall System Width   61'
      (including column allowances)
- o Min. Carousel Travel Speed   60 ft/min

3.2.5   Carousel Number 6 has the following configuration:

- o # Carousels   I
- o Clear Height Available   10' 10"
- o Approximate System Height   10'
- o Carousel Bin Height   9' 3"
- o # Carriers per Carousel   70
- o Total # Carriers (Bins)   70
- o Carousel Bin Size (approx.)   21.5"W x 22"D
      (for 20"W x 24" L totes)

o	# Shelves per Carrier	10
o	# Shelves per Carousel	700
o	Total # of Shelves	700
o	Tiers for 7" High Totes	5
o	Tiers for 10" High Totes (for high loads maximum)	5
o	Total Tote Sotrage Locations	700
o	Maximum Weight Per Carrier	800#
o	Weight Capacity Per Shelf	50#
o	Overall System Length	71'
o	Overall System Width	7.5'
o	Carousel Travel Speed	80 ft/min

The carousel system configuration is shown in Honeywell Drawing #MHS-1 (Rev. A).

3.2.6   In order to allow potential suppliers to use their standard equipment and system configurations, the exact system configuration may vary within the following limits:

o	Minimum Storage Capacity	680 Totes
o	Overall System Maximum Height	10' 10"
o	Overall System Length	75'
o	Overall System Width (including column allowances)	8'
o	Min. Carousel Travel Speed	60 ft/min

3.2.7   The configuration must include adequate space at the rear of the system to allow for system main-tenance and emergency parts picking during periods when the robots, conveyors, or control system are not working. Standard foot pedal controls must be provided at the rear of each carousel in order to allow such operation. It is also preferred to have at least one aisle parallel to the carousel length for maintenance access to the back of the system if the configuration and layout can provide sufficient space.

3.3 Robot System Configuration

3.3.1   The robotic carousel loading/unloading system will be made up of the following major system elements:

        o   Fixed-Position Robot Structures
        o   Lifting Platforms
        o   Tote Input/Output Devices
        o   Local Controls
        o   Control Enclosures
        o   Other Mechanical and Electrical Support Items

3.3.2   The robot system has the following configuration:

o # of Robots	10
o Overall Height	10' 10"
(slightly more height may be available between beams if necessary)	
o # of Input/Output Levels	2
o # of Shelf Levels To Access	16
(except carousel #6)	
o # of shelf levels to access	10
(Carousel #6)	
o Load Capacity	50
o Length and Width of Robot	5' x 5'

3.3.3   In order to allow potential suppliers to use their standard equipment and system configurations, the exact robot system configuration may vary within the following limits:

o Maximum System Height	12'
(to be coordinated with Honeywell facilities group)	
o Robot Maximum Size	7' x 7'

3.3.4   The robots may transfer the totes onto conveyor spurs on either side of the robot, may pass the totes straight through, or rotate the totes as required by the robot design proposed.

3.3.5   Robots that can access more than one carousel each may be quoted as an option, but the total impact on system cycle times, layout and throughput must be stated so that the Honeywell team can evaluate the option.

3.4 Vertical Carousel System

3.4.1   The vertical carousel system for storing and retrieving inspection folders will be made up of the following system elements:

        o   Vertical Carousel Conveyor
        o   Supporting Structure and Enclosure
        o   Shelves for Lateral Filing
        o   Local Microprocessor Controls
        o   Other Mechanical and Electrical Support Items

3.4.2   The verical carousel system has the following configuration:

o # Carousels   1
o Clear Height Available   10' 10"
o Approximate System Height   10' 6"
o Total # Carriers (Shelves)   20
o Carousel Shelf Size   90"W x 15"D
   (for legal size folders)
o Maximum Weight Per Shelf   300#
o Overall System Length   9'
o Overall System Width   6'
   (posting shelves on both sides)

The vertical carousel system configuration is shown In Honeywell Drawing MHS-1 (Rev. A).

3.4.3   In order to allow potential suppliers to use their standard equipment and system configurations, the exact system configuration may vary within the following limits:

o Minimum Storage Shelves   18
o Overall System Maximum Height 12'
   (must be coordinated with Honeywell
   facilities)
o Overall System Length   10'
o Overall System Width   7'
(including posting shelves)

3.4.4   The vertical carousel configuration must Include openings, open shelf configurations, operator controls, and posting shelves on both sides In order to provide easy access for two operators. The system must Include safety features to prevent one operator from rotating the carousel while the other operator is accessing the other opening. The configuration must also Include adequate space to allow for system maintenance.

3.4.5   The vertical carousel system must also Include the necessary equipment for Interfacing with the MHS computer control system and a "light bar" system on each opening for Identification of the proper IPI (Inspection Procedure Information) folder location.

3.5 Horizontal Carousel Design Requirements

3.5.1   The carousel systems shall be supported entirely from the floor In the Honeywell Avionics facility. No support from the building walls or roof other than minor bracing will be allowed.

3.5.2   The carousel load carriers may be supported from
            either a bottom framework or a top framework
            design. In either case, a framework and guide rail
            shall be provided at both the top and bottom of the
            carousel carriers.

3.5.3   The support columns for the top carrier support
            framework shall be dual post pairs rather than
            single posts. Sway braces shall be provided in order
            to prevent movement of the structure under uneven
            loading and acceleration/deceleration conditions.

3.5.4   Foot plates for the framework support columns
            shall be sized to distribute the floor loading
            within the specified floor capacity limits. Foot
            plates shall have provisions for adjusting the
            level of the system and shall be lagged into the floor
            with 2" (minimum) taper bolts.

3.5.5   The carousel system structure shall be constructed using
            a modular design so that the sections can be transported
            to the site for fast initial installation. The modular
            structure also allows future movement to a new
            location or changes in system length. The modular
            structure shall use bolted connectors and splice
            plates for linking the modules together. The
            sections shall not be over 10 feet in length.

3.5.6   The carousel load carrier baskets and shelves shall
            be constructed from formed and welded, zinc or nickel
            chrome plated steel wire. All wire intersections
            shall be welded. The carrier backs may also be
            constructed from wire or they may be manufactured from
            sheet steel with punched slots to accept the shelf
            and side wires. If solid steel backs are provided,
            they shall be supplied with a conductive, non-rusting
            finish.

3.5.7   The load support shelves shall be securely locked in
            position and tier spacing shall be fully
            adjustable on 3" to 4" increments.

3.5.8   Carrier and load weight shall be transmitted
            through the carrier structure by a major vertical
            structural member. This structural member may be a
            steel strap, a steel carrier back, or oversized
            vertical wires.

3.5.9   Each carrier shall be capable of supporting at
            least 800 pounds of load weight. All loads will
            be stored in the tote sizes that have been

defined. The number of totes stored in each carrier, placement of the totes, and weight in each tote will be random within the specified limits.

3.5.10   Exact requirements for wheels, bearings, and chains are to be specified by the carousel manufacturer, by the following minimum requirements shall be met:

1. Load bearing and guide wheels are to be rated for at least a 200 percent safety factor over design weight and positioned to properly interface with the support track. Each wheel shall have a roller bearing at the roller axis and dual thrust bearings shall be provided at the rotating axis. Sealed-for-life bearings are preferred, and a suitable bearing life shall be stated by the manufacturer.

2. Wheels shall be drop forged or rolled steel with heat treated treads and flanges or cast iron with chilled tread and shall have a minimum tread hardness of 425 Brinell. Bearings shall be selected to provide a minimum B-10 life of 25,000 hours.

3. The drive chain shall be formed by connecting each carrier with pressed steel links using Oilite bushings for lifetime lubrication.

4. Drive and idler sprockets shall be fabricated from plate steel, forgings, or castings. Castings and forgings shall be designed with an allowable stress not to exceed 20 percent of the ultimate strength of the material.

5. A sheet-metal drip/dust guard shall be provided under the upper chain and trolley system to prevent oil or dirt from falling on stored material.

3.5.11   Each carousel system shall be driven by two drive units, with one located at each end of each carousel. Each drive unit shall include the motor, gear reducers, and drive linkage.

3.5.12   Each drive motor shall be at least 1.5 HP and must be
          U.L. approved. The motors shall be direct current,
          totally-enclosed, non-ventilated motors rated for
          continuous duty. Transformers shall be provided by the
          carousel contractor, to convert the 480-volt, three-phase
          building power to the DC voltage level required.

3.5.13   Gear boxes shall be designed for continuous duty and
          shall be oil filled and provide an easily accessible
          oil level indication.

3.5.14   Power transmission to the drive sprockets may be either
          direct gear drive or chain drive. The drive system
          shall be fully enclosed in order to meet Honeywell safety
          requirements.

3.5.15   All drive system components shall be designed in
          accordance with a modular structure so that components
          may easily be removed and replaced.

3.5.16   In addition to the items already noted, there are several
          other mechanical safety features that shall be
          incorporated in the carousel system design:

          1. All structural components of the carousel systems
              shall be designed with at least a 200 percent
              safety factor.

          2. All carousel components shall be designed to
              minimize potential safety problems for operators
              or maintenance personnel. All sharp edges shall
              be rounded or otherwise suitably protected.

          3. Carousel shelves shall be sloped sufficiently to
              prevent loads from sliding out of carriers
              at any time except when accessed by the robot
              system or personnel.

          4. Normal carousel operation will not require
              operators to interface directly with the
              carousel system and the area will be secured.
              During operation from the rear of the
              carousel systems for maintenance or backup
              operation, manual interface will be
              required. Suitable signs and floor markings
              shall be provided by the carousel contractor
              to identify the areas of potential danger to
              operators at the rear of the system.

3.5.17   Power supply from the Honeywell-provided junction boxes to the carousel motors shall be enclosed in approved conduit and interfaced to the junction boxes through standard conduit couplers.

3.5.18   Power panels and consoles shall meet NEMA 12 requirements, with the exception of keyboard control units. All panels for each system shall be identical and interchangeable. Cables must be routed and neatly tied within panel enclosures. All internal connections shall be made through labeled terminal strips.

3.5.19   All exposed metal parts shall be solidly grounded by connection to the building ground loop.

3.5.20   Cables shall be identified with standard alphanumeric ID sleeves at origin, terminus, and both sides of any junction blocks. Labeling is required on all terminals, relays, starters, switches, isolators, controls, safety devices, fuses, and other components at control console and at local terminus areas. All motors and other remote electrical components shall be label identified to correspond with their ID numbers on electrical prints and schematics.

3.5.21   The motors for each carousel shall be protected independently with current overload devices. The current overload devices for each pair of carousel motors shall be interconnected to prevent single motor operation. A time delay circuit shall be provided to prevent instantaneous reversals.

3,5.22   The system local control unit must provide the motor control functions, the interface with the MHS control system, and the operator keyboard for maintenance and backup operation.

3.5.23   Control of the DC motors shall be accomplished by the local controller microprocessor with feedback from position sensing equipment. In response to a location command (carrier number), the control shall smoothly accelerate the carousel, run at full speed, and then decelerate to a final stopping position for input or output. The control shall step the motors through multiple speeds in order to achieve the smoothness and positioning accuracy required. The control shall automatically rotate the carousel in the direction that will minimize travel time and it shall reverse direction to obtain final positioning, if necessary. Position sensing shall be accomplished through either a shaft encoder or a discrete target sensing device for each carrier.

3.5.24   A secondary device shall be provided by the carousel
          supplier to positively verify correct carousel carrier
          positioning prior to tote extraction or deposit. This
          device may be a photoelectric, infrared, or magnetic sensor
          that is mounted at the robot I/O end of each carousel
          system and which detects the final carrier positioning.
          This secondary sensor feedback is part of the information
          that must be fed back to the local controller in order
          for it to give the robot system controller the
          message that the carousel is properly positioned.

3.5.25   In addition to the safety devices already described, each
          carousel system shall include emergency STOP/RESET
          buttons located at both ends of each system. Activation
          of the STOP button shall interrupt motor power to the
          carousel and shall brign the carousel to a controlled
          stop in minimal time. RESET button activation shall allow
          resumption of operation.

3.6 Robot System Design Requirements

3.6.1   The robot systems shall be supported entirely from the
          floor in the Honeywell facility. No support from the
          building walls or roof other than minor bracing will be
          allowed.

3.6.2   Foot plates for the robot structural columns shall be
          sized to distribute the floor loading within the
          specified floor capacity limits. Foot plates shall have
          provisions for adjustment to level the system and shall be
          lagged into the floor with 2" (minimum) taper bolts.

3.6.3   The robot system shall be constructed using a modular
          design so that the sections can be trans-ported to the
          site for fast initial installstion. The modular structure
          also allows future movement to a new location.

3.6.4   All structural components of the robot system shall
          be designed with at least a 200 percent safety factor.

3.6.5   Any mechanical stops used to control robot motions shall
          include cushioning devices.

3.6.6   Reference position sensors shall be mounted on a
          stationary portion of the robot structure that is isolated
          from any vibration.

3.6.7   Robot motions in all directions shall be constrained with physical end stops as safety devices that positively limit the maximum travel of the componentsand tote loads being transported.

3.6.8   Exact requirements for wheels, bearings, and chains are to be specified by the robot manu-facturer, but the following minimum requirements shall be met:

1. Load bearing and guide wheels are to be rated for at least a 200 percent safety factor over design weight and positioned to properly interface with the support tracks.Each wheel shall have a roller bearing at the roller axis. Sealed-for-life bearings are preferred, and a suitable bearing life shall be stated by the manufacturer.

2. Wheels shall be drop forged or rolled steel with heat treated treads and flanges or cast iron with chilled tread and shall have a minimum tread hardness of 425 Brinell. Bearings shall be selected to provide a minimum B-10 life of 25,000 hours.

3. Lifting chains shall be designed with at least a 6:1 safety ratio with pressed steel links using Oilite bushings for lifetime lubrication.

4. Drive and idler sprockets shall be fabricated from plate steel, forgings, or castings. Castings and forgings shall be designed with an allowable stress not to exceed 20 percent of the ultimate strength of the material.

5. Any air cylinders used shall be sized to handle a maximum of 200 percent of the normal air flow requirements. All air-driven equipment shall conform to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Code.

6. All compressed air subsystems serving any mechanisms shall be designed to incorporate, but not be limited to:

a. Manual shutoff valve (one for each subsystem or item requiring compressed air).

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b. A properly sized combination air filter and pressure regulator designed for severe industrial use and incorporating filters that can be cleaned, and components that are replaceable.

c. Electrically piloted air valves.

d. Speed control valves.

e. Two way, or one way with spring return - as required by design - air cylinders rated for severe industrial use and incorporating replaceable wiper rings, end cushions, speed control valves, and mufflers.

f. Common mounting plates or brackets wherever reasonably possible.

g. All compressed air work installation and design shall conform to ANSI B31.1. All piping shall be cut accurately to measurements established for the work by the robot system contractor and shall be worked into place without springing or forcing. Piping shall be installed to provide flexibility for vibration stress and shall be supported and anchored so that strain from weight and thermal movement is not imposed on the equipment.

h. Honeywell will provide shop air to a cutoff valve located on the closest building wall to the robot installation area. The robot contractor shall pipe the air and provide regulation to the robot systems.

I. All piping connections shall be threaded in order to permit easy disconnection or replacement. Reducing fittings shall be used for all changes in pipe sizes.

7. Hydraulic systems are not to be used in the design of the robot devices.

8. All counterweights shall be confined in an enclosure to prevent the presence of

:ersonnel   beneath the counterweight   and to
avoid obstructions in the counterweight   path.
The arrangement shall   provide   a means to
restrain   the falling   weight in case of failute
of the normal counterweight support.

3.6.9   The   robot   load   carriers shall   be   designed   to
          positively   hold totes in position during movement and
          interface effectively with the corousel   tier levels and
          the input and output conveyors.

3.6.10   The   exact design of the load transfer   mechanism will
          not   be specified, so that alternative standard   designs
          may be used. Techniques for   a pass-through   design or
          right angle transfers are acceptable.

3.6.11   Tote   positioning   for loads to be   input   by   the robot
          devices shall   be   accomplished   accurately   by   the   input
          conveyor system.   Positioning guides and physical stops
          ahall control the tote positioning.

3.6.12   The   robot   systems   shall   position   within   1/8"
          horizontally and vertically. The   tolerances   of
          successive   positionings must not be   cumulative.   The
          robots shall be designed to position slightly above the
          deposit elevation and slightly below the retrieval
          elevation in order   to assure   proper interface with the
          carousel carriers.

3.6.13   Each   robot system motion shall be driven by   D.C.
          electrical   motors or   electrically-activated   air
          cylinders.   Each motor shall be be U.L. approved. The
          motors   shall   be   direct   current,   totally-enclosed,
          non-ventilated   motors   rated   for   continuous   duty.
          Transformers shall be provided by   the carousel
          contractor, to convert the 480-volt, three-phase building
          power to the DC voltage level required.

3.6.14   Power   transmission to the drive sprockets may   be either
          direct   gear drive or   chain   drive.   The drive   system
          shall be fully enclosed in order   to meet   Honeywell
          safety requirements. All   drive components must meet ASA
          specifications.

3.6.15   All   drive system components shall   be   des,gned   in
          accordance with   a   modular structure   so that components
          may easily be removed and replaced.

3.6.16   A positive method shall be provided to decelerate the
          robot quickly to a stop under emergency conditions.

3.6.17   In addition to the Items already noted, there are several
          other   mechanical   safety   features   that shall   be
          Incorporated In the carousel system design:

          1. All   structural components of   the   robot systems
             shall be designed with at least a 200 percent safety
             factor.

          2. All robot components shall be designed to minimize
             potential   safety problems   for operators or
             maintenance personnel.   All sharp edges shall be
             rounded or otherwise suitably protected.

          3. Robot load carrying platforms   shall   be designed to
             prevent loads from moving out of position any time
             except when accessed by the robot system.

          4. Normal robot operation will not require operators to
             Interface directly with the robot system and the
             area will be secured.   However, during maintenance
             or backup operation, manual Interface will be
             required. Suitable signs and floor markings shall
             be provided by the robot contractor to Identify
             the areas of potential danger to maintenance
             personnel.

          5. A mechanical free-fall braking mechanism shall be
             Incorporated In order to prevent the load from
             dropping In the event of   a broken   drive
             mechanism. This device shall be activated by any
             slack   drive mechanism   or   overspeed   condition,
             and shall stop the vertical motion within 6 Inches
             In a free-fall situation.

          6. Devices shall be Included for all vehicle motions
             that will stop the robot and prevent damage if
             a physical overload condition Is encountered.Such
             physical overloads could be causedby an overweight
             load (a load that Is approximately 30 percent
             overweight) or a physical Interference.

3.6.18   Power supply from the Honeywell-provided Junction boxes to
          the carousel motors shall be enclosed   In approved
          conduit   and Interfaced to the   junction boxes through
          standard conduit couplers.

3.6.19   Power   panels   and   consoles   shall   meet   NEMA   12
          requirements, with the   exception of   keyboard control
          units. All panels for each system shall be identical and
          interchangeable. Cables must be routed and neatly tied
          within panel enclosures. All internal connections shall
          be made through labeled terminal strips.

3.6.20   All exposed metal parts shall be solidly grounded by
          connection to the building ground loop.

3.6.21   Cables shall be identified with standard alphanumeric ID
          sleeves at origin,   terminus,   and both   sides of any
          junction blocks.   Labeling is required   on all
          terminals, relays,   starters, switches,   isolators,
          controls, safety devices, fuses, and other components at
          control console and at local terminus areas. All motors
          and other remote electrical components shall be label
          identified to correspond with their ID numbers on
          electrical prints and schematics.

3.6.22   The   motors   for   each robot   shall   be   protected
          independently with   current overload   devices. A time
          delay circuit shall be provided to prevent instantaneous
          reversals.

3.6.23   The   system local control unit must provide the motor
          control functions,   the interface with   the MHS control
          system,   and the operator keyboard for maintenance and
          backup operation.

3.6.24   Control of the DC drive motors shall be accomplishedby
          the   local   controller microprocessor with feedback from
          position-sensing equipment. In response to a   location
          command (level and store or retrieve), the control shall
          smoothly manage the robot motions and decelerate to a
          final stopping position for input or output. The control
          shall step the motors through multiple speeds in order to
          achieve   the   smoothness   and positioning accuracy
          required.

3,6.25   Position sensing shall be   accomplished   through shaft
          encoders,   a discrete target sensing   device for   each
          level, or   ultrasonic   devices. The position   sensing
          device   shall   be   designed   to simplify   future
          re-programming to add or delete tier levels or change tier
          spacing.

3.6.26   In   addition   to   the   safety   provisions   already
          identified,   several   additional   items   shall   be
          included:

1. Load Presence Detector - Each robot shall include a load presence detector that verifies load presence on the lift table after a tote retrieval cycle and confirms tote absence on the lift table after a tote deposit cycle.

2. Full Bin Detector - Prior to attempting to deposit a tote in a carousel opening, a detector shall verify that there is not a load already present.

3. Pickup Position Sensor - A sensor shall be provided to verify that the robot lift table is in the proper position to receive or discharge a load prior to allowing the load to move on the conveyor.

3.6.27   The local controller shall be constructed in accordance with a modular design that allows simple replacement of circuit boards or other electronic modules in order to permit easy maintenance and fault diagnosis.

3.6.28   The local controller shall include provisions for using maintenance and debugging programs for diagnosis of system problems.

3.6.29   ESD protection for all components in contact with containers being handled shall be conductive, grounded and not static generating.

3.7   Robot and Carousel Performance Requirements

3.7.1   The noise level of the completed carousel and robot system installation under all operating conditions must not exceed 65 dBA, when measured at a point three feet from the carousels and robots at an elevation of four feet above the floor level.

3.7.2   The maximum carousel carrier retrieval time for clockwise or counterclockwise travel of the most remote carrier to the I/O position must not exceed 65 seconds, including acceleration, deceleration, final positioning, and transmission of a cycle-complete message to the control system. The average cycle time shall not exceed 35 seconds.

3.7.3   The maximum robot cycle time shall not exceed 40 seconds, including acceleration, deceleration, final positioning, and transmission of a cycle-complete message to the control system. The maximum cycle time is based on the following cycle sequence:

1. Start with lift table in the low pickup position and a tote positioned on the conveyor in the pickup position.

2. Pick up the tote.

3. Move to top tier elevation.

4. Deposit load.

5. Return lift table to the low pickup position.

The average cycle time shall not exceed 25 seconds. Average cycle time is based on the same sequence, except accessing a tote position at the highest tier level above the floor level.

The carousel and robot system shall be designed to maximize throughput by allowing the carousel to rotate any time the robot is not actually depositing or retrieving a tote from the carousel bins.

The supplier shall state the total time required for both cycles and the times for each of the movement components.

3.7.4   All exposed carousel and robot components that are not plated shall be painted with an enamel finish using colors specified by Honeywell. Touch up painting shall be required after installation for any nicks, scrapes, voids, or other inconsistencies in paint color, texture, or covering.

SECTION 4.0

TOTE CONVEYOR SPECIFICATION

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4.0 TOTE CONVEYOR SPECIFICATION

4.1 General Requirements

4.1.1   The conveyor system required for the Honeywell Avionics Division MHS Automation Project is designed to handle the same standard material handling totes that are planned for use in the carousel storage and retrieval system. The conveyor system must handle empty totes and totes containing a wide variety of production parts and supplies.

4.1.2   The conveyor system configuration must be approximately as shown in the general Honeywell System Layout Drawing MHS-1 (Rev. A). Exact conveyor placement, radius of curves, and other configuration details may be modified to suit specific manufacturer's standard conveyor components and to produce the most cost effective and reliable system instal-lation, provided that the functionality of the system is not adversely affected.

4.1.3   Load sizes and weights on the conveyors will be as follows:

o   Lewis ASD polypropylene conductive totes (or equivalent) 20" wide x 24" long x 4", 7" and 10" high with a maximum weight capacity of 50 pounds. The 10" totes will have a maximum load height of 12". Totes will be provided by Honeywell and are not part of the proposal requirements.

4.1.4   Conveyor system elevations will be approximately 36 to 48 inches above floor level unless otherwise specified.

4.1.5   Openings in the building fire walls and other existing walls in the Honeywell facility will be provided by Honeywell in order to allow the tote conveyor to pass through the walls. Honeywell will coordinate the opening size requirements with the selected system contractor in order to assure adequate clearances and proper location. The system contractor must provide the fire doors and local controls that will clear the doorways and drop the doors at the fire wall openings upon receipt of a signal from the Honeywell-supplied smoke detection system.

4,2 Tote Conveyor Configuration - Outbound Tote Flow

4.2.1   Part totes will be stored in the Carousel AS/RS and
            retrieved automatically under computer control. Totes
            will be automatically retrieved from the carousel
            system, removed by the robots, and placed on the
            conveyor output spurs. The spurs must be oriented to
            interface properly with the type of robotic
            input/output devices proposed.

            The totes may then be moved to individual picking
            stations for batch or individual order picking, to the
            receiving and stocking stations, or to the inspection
            dispatch station for selection of parts for receiving
            inspection. In addition, parts will be routed in
            totes to the individual inspection work stations and
            the order consolidation area.

            Totes containing parts for the automatic insertion Area
            will be stored in carousel number 6 and accessed through
            the robot and conveyor spurs at the rear of carousel 6.

4.2.2   Empty totes will also be stored in the carousels and
            in an empty tote conveyor section. Empty totes will
            be dispatched under computer control or upon operator
            request to the Receiving, Receiving Inspection
            Dispatcher, Receiving Inspection work stations,
            Stocking, Automatic Insertion, and Picking Areas.

4.2.3   Totes that are outbound from the Carousel AS/RS will
            be placed by the robots on the top level of the tote
            conveyor as shown on Honeywell Drawing MHS-1 (Rev. A).
            The actual queue placement and interface with the
            robots can be adjusted to meet the requirements
            of the robot device proposed,. A queue space for at
            least two totes to accumulate on each of the robot
            output spurs must be provided.

4.2,4   The totes will then merge onto the main outbound
            conveyor and travel through the outbound laser
            scanner. Merging logic must be provided to assure that
            there will be a smooth flow of totes through this
            section, including merging with totes that enter from
            the bypass conveyor and the empty tote queue. Totes
            entering from the bypass and empty tote conveyors will
            have priority over the totes that are coming from the
            Carousel AS/RS. Accumulation for at least ten totes on
            the main outbound conveyor prior to the laser
            scanner must be provided.

4.2.5   The system supplier must provide the moving beam laser scanners and the tote bar code labels to be used for tote routing. The tote labels must be permanent high or medium density Code 39 (three-of-nine) sequential labels that may be reliably read by the fixed laser scanners, hand-held wand scanners and hand-held laser scanners used in this system. Each bar code label must include an alphanumeric interpretation line that presents the tote number in human-readable form. They must be designed to assure accurate readability and long life under heavy use conditions. The labels must be unaffected by soap and hot water washing, as well as the normal operating conditions and environment of the Honeywell facilities. The supplier must provide and install two identical labels on opposite sides of each of the 12000 totes provided by Honeywell.

4.2.6   The fixed laser scanners to be used in this application must have a first time read rate of 99.5 percent and be able to read accurately under the specified environmental conditions. The readers must also meet the following minimum requirements:

o   The laser scanner must read each code more than once to verify the accuracy of the reading.

o   The scanner must have sufficient depth of field to permit accurate reading of totes on the conveyor.

o   The scanner must read tote bar codes that are tilted, skewed or pitched at up to 30 degrees from normal plane.

o   The scanner must read at conveyor speeds up to 100 feet per minute.

o   The scanner must be enclosed in its own NEMA enclosure.

o   The scanner must include any necessary safety devices or warning signs to assure personnel safety.

o   The scanner must include adequate shock or vibration isolators and mountings to provide reliable service.

o   The scanner must include quick disconnect fittings to allow easy replacement in the event of scanner failure.

4.2.7   Totes that have been scanned by the outbound laser
            scanner will then either travel straight through the
            opening in the wall or be diverted toward the
            Inspection Area. Totes that go straight ahead will
            either continue to the Stocking, Picking and Receiving
            stations or divert to the right to the
            Sortation/Consolidation Area. Totes that have not been
            successfully read by the laser scanner, or are totes
            without valid destinations will be diverted to the
            left immediately after scanning into a reject spur for
            manual problem resolution.

4.2.8   Totes that are diverted into the reject spur will
            accumulate in a six-tote gravity roller conveyor queue.
            Once an operator has resolved the problem, the totes
            will be manually transferred to the outbound conveyor
            for re-scanning. Totes that are being returned to
            storage may be moved to the lower (inbound) level
            through local push button activation of a scissors lift
            and manual transfer between the conveyors. The gravity
            reject conveyor section must include a sensor to
            detect the presence of each load that enters the
            station and send a signal to the computer system
            when the queue is full.

4.2.9   Totes that travel straight ahead to the receiving,
            stocking, and picking stations must be diverted into
            the correct conveyor queues at their destination work
            stations.

4.2.10   Totes that have destinations in the Receiving
            Inspection Area must be diverted into the Receiving
            Inspection conveyor spur. Totes that are bound for
            the Inspection dispatcher or individual receiving
            inspection work stations will then be diverted into
            the appropriate conveyor queues.

4.2.11   Totes that are diverted to the right and have a
            destination in the consolidation area will be
            directed into the two accumulation conveyors in this
            area for regular picks or continue straight ahead and
            accumulate on the conveyor designated for hot picks.
            Totes must be distributed between the two regular pick
            spurs so that the number of totes in each spur will
            remain approximately the same. Queue space for at
            least eight totes in each of these spurs must be
            provided, plus a queue of at least four totes in the hot
            pick spur.

4.3 Tote Conveyor Configuration - Inbound Tote Flow

4.3.1   Totes that are to be returned to storage or routed through the bypass conveyor or empty tote queue conveyor will be placed by operators on their work station output conveyor spurs.

4.3.2   The totes must accumulate on the station output conveyor spurs and automatically feed onto the lower level Inbound conveyor. Merging controls and logic are required for each merge point.

4.3.3   Inbound totes will travel on the lower level conveyor until they pass through the inbound laser scanner as shown on Honeywell Drawing #MHS-1 (Rev. A). Accumulation capability for at least twelve totes Is required prior to the inbound laser scanner.

4.3.4   After totes pass through the inbound laser scanner they may be diverted into the bypass loop, the empty tote conveyor queue, the inbound reject spur, or moved to one of the carousels for storage. Tote height scanners must be provided and installed to assure that the totes are stored in the right height openings, and that over-height loads are rejected.

4.3.5   Totes that are to be routed through the bypass conveyor will be diverted from the main inbound conveyor to the bypass conveyor, moved up an incline to the outbound level, and merged into the outbound tote flow.

4.3.6   Empty totes that pass through the inbound laser scanner will be diverted into the empty tote conveyor queue whenever space is available in the queue. The empty tote queue conveyor must provide queue space for at least eight empty totes. When space is not available in the queue, the empty totes will be automatically stored in the Carousel AS/RS.

4.3.7   Totes that are diverted into the inbound reject conveyor spur will accumulate in a six-tote gravity roller conveyor queue. Once an operator has resolved the problem, the totes will be manually transferred to the inbound conveyor for re-scanning. Totes that must be transferred to the upper (outbound) level may be moved through local push button activation of a scissors lift and manual transfer between the conveyors.

4.3.8   Totes that are moved to the carousel/robot queue spurs will be directed to specific spurs through the control system logic. Queue space for at least two totes on each inbound carousel/robot spur is required.

4.3.9   The conveyor control logic must provide for sequential
             shut down of preceeding conveyor sections when full
             queue conditions are encountered in any of the
             accumulation sections. The system must shut down
             only the minimum sections that are required to
             avoid over-filling each queue, and then
             automatically re-start the conveyor sections as the
             queues clear.

4.4 Tote Conveyor Configuration - Work Stations

4.4.1   A standardized work station conveyor configuration is
             indicated for most of the operator work stations
             shown on Honeywell Drawing # MHS-1 (Rev. A). The
             configuration, which is shown in more detail on
             Honeywell Drawing # MHS-2 (Rev. A), uses two input
             conveyors, a return conveyor, and a ball transfer
             table for each operator work area. Generally, two
             operators will share one tote return conveyor, and one
             of the input conveyors. The input queues must each
             have capacity for accumulation of three totes,
             and the output queues must each have capacity
             for accumulation of four totes. The design is based
             on using inclined gravity roller conveyor for each
             queue, but powered alternatives will also be
             considered.

4.4.2   The ball transfer table in each of the standard-ized
             work stations is to be used by the operators to position
             their totes as required for performing their work and
             to aid them in transferring the totes to the output
             conveyor spur without any need for lifting the totes.
             It is anticipated that the operators will pull the
             totes over a roller stop from the input queues onto
             the ball transfer table, and when they are ready to
             return the totes they will roll them to the return spur
             and release them.

4.4.3   One of the two input queues at the standardized work
             stations will generally be used for parts totes and
             the other for empty totes. Two adjacent operators
             will generally share the input queue that is used to
             deliver empty totes.

4.4.4   The inspection dispatcher work station is designed to be
             operated by one dispatcher or shared by two. The
             configuration includes the following five conveyor
             spurs:

PLAN VIEW

ROLLER STOP

MT TOTES →

WORK SHELF

BALL
TX

⬡ OPERATOR # 1

PARTS →

← RETURN

WORK
TABLE

PARTS →

BALL
TX

⬡ OPERATOR # 2

MT TOTES →

PARTS →

⬡ OPERATOR # 3

↑ ← RETURN

WORK
TABLE

ELEVATION VIEW

DELIVERY →

←

RTN
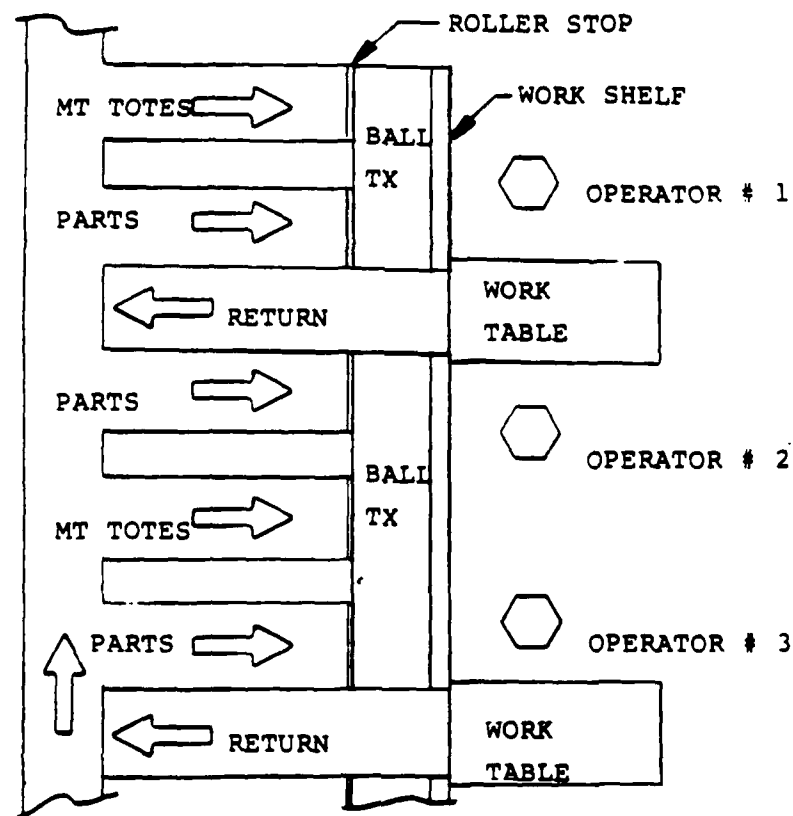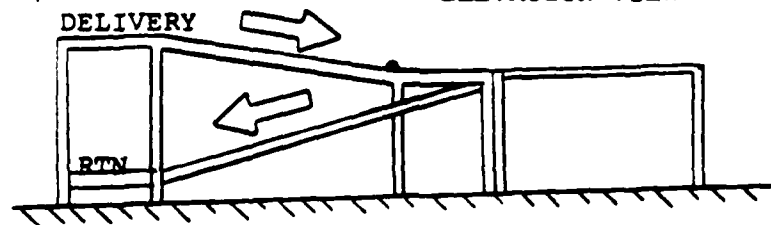
STANDARDIZED WORK STATION CONCEPT

DRAWING # MHS-2 (REV. A)

SHEET 1

PLAN VIEW

CRT & KEYBOARD
BAR CODE WAND
WORK SHELF

BALL
TX

OPERATOR # 1

OPERATOR # 2

BALL
TX

OPERATOR # 3

DIGITAL SCALE

BAR CODE PRINTER

CRT PEDESTAL

ELEVATION VIEW

SHELVES UNDER BALL TX TABLE

STANDARDIZED WORK STATION CONCEPT

DRAWING # MHS-2 (REV. 4)

SHEET 2

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QTY	FROM	TO	FOR
2	Top Conveyor	W/S	Totes from carousels
1	W/S	Bottom Conveyor	Return totes to carousels
1	W/S	Top Conveyor	Dispatch to Inspection
1	Bottom Conveyor	W/S	Return from Inspection

The Inspection dispatchers will utilize empty totes that are returned from the stocking work stations and queued in the area, as required.

4.4.5   The standardized work stations must be ergonomically designed to facilitate efficient operator access from a standing position. The actual work benches and chairs are not part of this specification, but provisions for all peripherals, a small work counter and shelves under the counter must be provided by the system contractor.

The counter as shown on Drawings # MHS-1 (Rev. A) and MHS-2 (Rev. A) should be approximately 9 inches wide and include a conductive surface. Conductive, non-corroding steel shelving sections approximately 2 feet deep with at least two shelves and solid backs must be mounted under the conveyor input spurs for storage of operator supplies, peripherals and reference materials.

4.4.6   The major system peripheral equipment is to be located at the operator workstations as shown in MHS-2 (Rev. A) Sheet 2. The equipment includes a CRT and keyboard, wand scanner and bar code ticket printer (shared between two operators). Other peripheral equipment, such as scales, staplers and bag dispensers will be provided by Honeywell and located on the work bench. The CRT, keyboard, and wand scanner should be located on a fully adjustable pedestal supported by the workstation and the printer should be located on the work bench for access by both operators. The approximate peripheral equipment locations are indicated on MHS-2 (Rev. A) Sheet 2. Convenience outlets for four 110 volt plugs must be provided at each work station.

4.4.7   In the Receiving Inspection Area there will be ten
         roller gravity conveyor queues to supply the thirty-six
         Inspection work stations. Each queue must provide
         space to divert and accumulate two totes. A gravity
         conveyor return with accumulation space for at
         least one tote must be provided under each delivery
         spur. No other provisions for special workstations or
         peripheral equipment are required in this area.

         The system contractor must supply and install the flow
         rack sections shown on Drawing # MHS-1 (Rev. A). Each
         section should have four levels of rollers sloped to
         deliver totes to the stocking stations and a bottom
         level sloped to return empty totes to the inspection
         dispatcher.

4.4.8   In the order consolidation area, empty totes will be
         returned manually to the lower level conveyor on three
         accumulation return spurs located under the delivery
         spurs in the area. Each of these spurs must provide
         accumulation for at least three totes. Provisions for
         pedestal mounting the two CRT's and keyboards and the
         two hand-held laser scanners must be included in this
         area.   .

         The system contractor must provide and install the
         shelving for order consolidation as shown on
         Drawing # MHS-1 (Rev. A). Each section must have five
         levels of shelving, and the permanent bar code
         labels for identification of 125 locations, and the
         picking light system as described in Section 5 of this
         specification must be provided and installed.

4.4.9   All workstations must include the appropriate
         diverter mechanisms and tote arrival/queue sensing
         equipment to allow automatic tote dispatching and
         return.

4.5 Conveyor Mechanical Requirements

4.5.1   The conveyor system structure must be constructed using
         a modular design so that individual conveyor sections
         can be transported to the site for fast installation.
         The modular structure must use bolted connectors
         and splice plates for linking the modules together,
         and module sections must not be over 20 feet in length.

4.5.2   Each conveyor section must be capable of
         sup-porting the weight of a maximum accumulation of
         totes.

4.5.3   Accumulation conveyors that are belt-driven may utilize twisted band drives or polybraid rope drives in place of the more conventional types of belt drives.

4.5.4   Conveyor rollers must be of the "pop out" type for personnel safety and for easy cleaning. Carrying rollers must be spaced on six-inch centers, maximum. If belt pressure contact rollers are used beneath the belt, they must be spaced on nine-inch centers, maximum. All rollers must be equipped with special quiet ball bearings that are externally sealed for protection against dust, and grease packed for life service.

4.5.5   All powered roller curves must utilize tapered rollers and must include side guards.

4.5.6   All belt conveyors must utilize a grip-faced conductive belt of at least three ply rating. All belt supporting or idler rollers must be equipped with ball bearings that are externally sealed for protection against dust and grease packed for life service. Conveyor belt drive/takeup provisions must be located in such a position as to promote maximum ease of tightening and replacement. All end idler rollers and takeup rollers shall be crown faced for positive belt centering. All take-up assemblies must have sufficient adjustment to compensate for maximum stretch of the belt.

4.5.7   Side guards are required on all tote conveyor, including transfers and curves. Guards must also be provided to protect all potential pinch points or entanglement points. Screen guarding must be provided under all conveyor over 6 feet in elevation.

4.5.8   Rough faced conveyor belts, retarding rollers, and other necessary features must be incorporated in order to assure tote stability on inclined or declined conveyor sections.

4.5.9   Conveyor system diverters may be of the pusher, V-belt, roller conveyor or swing arm type. The diverters must be designed to provide a smooth and reliable transfer with maintenance of the proper tote box orientation.

4.5.10 Exact conveyor widths, lengths and elevations must be determined by the system supplier in order to assure a cost effective and reliable design.

4.5.11   Conveyors must be painted with a minimum of one coat of primer and one coat of enamel. A custom paint color will be specified by Honeywell.

4.5.12   The conveyor design must incorporate features that minimize conveyor noise. Conveyor noise must not exceed a reading of 65 DBA when measured at a point 3 ft. away from the conveyor and 3 ft. above the floor.

4.6 Conveyor Electrical Requirements

4.6.1   All conveyor motors shall be right angle gear-head type with brakes where required. Electrical power supply shall be 480 volt, three phase, 60 hertz, All motors must be Class B insulated. Conveyor drives and motors must be installed alongside or underneath the conveyors on suitable mounts and in easily accessible locations.

4.6.2   All conveyor motors must include lockable power disconnects within 5 feet of the motor and at an easily accessible location for personnel in the area to use, if necessary.

4.6.3   All conveyor controls must be based on solid state designs and may include programmable logic controllers or microprocessor controls, Interfaces for computer control must be either RS232/422 or 20ma current loop. Honeywell programmable logic controllers, sensors and switches are preferred.

4.6.4   Motor control panels must be NEMA 12 and must be located in approximately the location shown in Honeywell Drawing # MHS-1 (Rev A). All transformers required for conversion from the Honeywell-supplied power must be provided by the system contractor. The motor control panels must include expansion space for the levels of growth required by JIC standards. All motors one-half horsepower or larger must be 480 volt three-phase with a standard industrial motor control center.

4.6.5   All other local conveyor control boxes must also conform to the NEMA 12 requirements.

4.6.6   Conveyor Emergency Stop buttons with manual resets must be located at locations adjacent to each operator work area along the conveyor. The Emergency Stops must control only the adjacent conveyor sub-system.

4.6.7   All tote sensing equipment must utilize LED
           devices, limit switches, or proximity detectors that
           are mounted such that they will not be affected
           by vibration. Honeywell Microswitch devices are
           preferred.

4.6.8   Air logic controls and diverter activation may be used
           in place of electrical controls whenever this approach
           provides significant advantages.

4.7 Conveyor System Throughput

4.7.1   The conveyor system throughput must be sufficient to
           meet or exceed the following minimum require-ments:

           o   Tote Conveyor System - The Tote Conveyor
               System must be able to handle an average
               throughput of 4000 totes into the carousel AS/RS
               and 4000 totes out per two shifts of daily
               operation (15 hours). The system must be
               capable of handling a peak throughput rate of
               at least 300 totes in and 300 totes out per
               hour.

           o   The system must also meet the average
               activity levels for Empty Tote Storage and
               Retrieval, Parts Tote Storage and Retrieval,
               Picking, Stocking, Inspection Dispatching,
               Bypass Loop, Receiving, Sortation, and
               Inspection functions as indicated in Section 6.0
               of this specification.

4.7.2   The conveyor system must be designed to simplify
           future expansion to allow Honeywell to handle a 25
           percent increase in volume.

SECTION 5.0

PROCESS CONTROL COMPUTER SYSTEM

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5.0 PROCESS CONTROL COMPUTER SYSTEM

5.1 General Requirements

5.1.1   The Process Control Computer System is the key element
of the MHS system that will allow total integration of
the storage and handling functions with the on-line
transactions, reports, inquiries, and file updates. The
computer system consists of a dedicated on-line
minicomputer, a real time communication link to
Honeywell's DPS-8 based HMS business software system, a
network of control elements to monitor and control
the various material handling and storage devices,
and a network of on-line peripheral devices including
CRTs, printers, bar code readers, and bar code
printers. An overview description of the functional
elements of the computer control system is presented below
in section 5.3.

5.1.2   The Process Control Computer System is made up of computer
hardware and software elements. Supplier proposals must
include all computer hardware for the Process Control
Computer System, but Honeywell reserves the option to
provide the computer equipment in the actual system
implementation. Since the existing HMS business system
utilizes Honeywell DPS-6/8 equipment Honeywell equipment is
preferred for the MHS computer system also. Other factors
being equal, vendor proposals utilizing Honeywell
equipment will be viewed more favorably.

Other computer control equipment may be proposed in order
for suppliers to take advantage of existing or
standardized software, or significant existing
expertise, if this will result in less cost or riskto
Honeywell. Supplier proposals should clearly state the
proposed computer hardware and software languages, and
give reasons for the selections. If equipment other
than Honeywell equipment is proposed, suppliers should
propose an option to utilize Honeywell equipment
instead, together with any additional proposed costs or
other factors, and justify these.

5.2 System Hardware

5.2.1   The system supplier shall be responsible for
determining the required control system hardware for
this application, and for determining the capacity and
configuration of the equipment such that the MHS design

parameters and system performance and throughput are met. For purposes of estimating the system requirements, a configuration was used that includes a Honeywell WCC 1250 IV computer with the appropriate system peripherals and memory capacity, Specifications on this equipment are included with this specification. The following operator peripheral devices are required:

7	Honeywell Display, Model 2 VIPS
4	Honeywell Printer, Model PRU7270
25	Hand-held bar code reader (wand)
2	Hand-held bar code reader (gun)
16	Bar code/text label printer

5.2.2   Honeywell will provide an enclosed computer room with raised floor, filtered power supply, and the necessary environmental controls. The locations for the equipment that will not be in the computer room are summarized as follows:

CRT Terminals and Bar Code Readers

16 at Picking/Stocking stations
2 at Receiving stations
2 at Inspection dispatch stations
2 at the consolidation stations
2 at Bulk area stations
1 at Stockroom Supervisor station
1 in Stockroom Manager's office
1 at Automataic Insertion picking station

Printers

1 at Inspection Dispatch stations
1 at the consolidation station
2 at Bulk area stations

Bar Code Printers

8 at Picking/Stocking stations (shared)
2 at Receiving stations
1 at Inspection dispatch stations (shared)
1 at consolidation station
2 at Bulk area stations
1 at Stockroom supervisor station
1 at Automatic Insertion picking station

5.2.3   All off-site software development work must be performed on the computer equipment supplied for the project or on compatible equipment available at the supplier's location. The plan for supporting this requirement must be outlined in the supplier's proposal.

5.2.4   Computer equipment and perIpherals to be supplIed for
             thIs project shall be covered by a one year hardware
             warranty after system ImplementatIon and acceptance by
             Honeywell.

5.2.5   Computer equIpment and perIpherals to be supplIed by
             the system contractor Includes all mIcroprocessor and
             programmable controller equIpment assocIated wIth
             control of the carousels, robots, and conveyor
             system. All sIgnal wIrIng from the computer to these
             devIces and to all system perIpherals must also be
             provIded by the system supplIer.

5.2.6   Honeywell wIll provIde power wIrIng and the
             assocIated conduIt and receptacles for all computer
             equIpment and perIpherals, wIth the exceptIon of the
             convenIence outlets specIfIed at each of the
             standardIzed work statIons, whIch wIll be provIded by
             the system contractor.

5.3 Control System Software

5.3.1   The MHS Process Control Computer system should be
             desIgned and Implemented In a hIghly modular
             fashIon such that all prImary system functIons can be
             tested and operated IndIvIdually and Independently.   A
             suggested approach to defInIng the basIc software
             subsystems Is as follows:

             5.3.1.1   TransactIon ProcessIng Subsystem - ThIs
                       subsystem would manage the the transactIon
                       logIc at all workstatIons and supervIsor
                       statIons, InteractIve termInal and scanner
                       transactIons, sequencIng and prIorItIzIng of all
                       transactIons, operator sIgn-on and securIty
                       features, operator performance statIstIcs,
                       order release processIng, and report/InquIry
                       InItIatIon. ThIs subsystem must create the HMS
                       transactIon Images and store them on a Journal
                       for all actIvItIes so specIfIed.

             5.3.1.2   Database Subsystem - ThIs subsystem would
                       manage all system fIles, access to and update of
                       any data record, fIle maIntenance functIons,
                       materIal locatIons, data securIty functIons, and
                       the IntegrIty of system data records. A
                       user-frIendly Query language Is hIghly desIrable
                       for the creatIon of specIal reports and
                       dIsplays.

5.3.1.3   Equipment   Monitoring   & Control Subsystem
           -This subsystem would manage and control   all
           material handling and storage equipment, tote
           traffic management, workstation queues, routing
           logic, and safety features.

5.3.1.4   Workstation I/O   Device Subsystem - This
           subsystem would manage the device status and
           communication for all peripheral communication
           devices, including terminals, bar code readers
           and printers, and report printers.

5.3.1.5   Data   Link   Subsystem - This subsystem   would
           manage the communication between the MHS
           computer and the HMS computer, file transfers and
           coordination, and other link functions.

5.3.2   System   software must be designed and   implemented to
           comply with the following guidelines:

           o The computer shall not stop processing unless
             absolutely required by system conditions.

           o Modes of operation should be included for
             Off-line, Test and Maintenance, and On-line modes
             for both stand alone (HMS not available) and
             interactive (HMS available).

           o Any hardware device errors or status changes in
             thematerial handling and storage equipmentshall be
             logged, acted upon positively whenever possible, and
             immediately brought to the system operator's
             attention.

           o All operator transactions shall have positive and
             quick response (no blank screens or lack of
             feedback) so operators are always aware of required
             actions.

           o The system shall perform self-test routines during
             startup, or on command, and shall verify that the
             necessary files are available on the system.

           o Closed loop messages, error messages, and
             timeouts shall be used to monitor system
             operation.

           o A redundant database scheme or equipment is required,
             and should be clearly identified in the supplier
             proposal, including complete operational description.

o All essential system information and status data
   must be preserved prior to any shutdown, whether
   planned or unplanned. This must include all
   memory resident system status data records and
   in-process material movement or transactions. A
   scheme must be included to utilize this
   information on system startup, and should be
   automatic or semi-automatic.

o A security code access system must be included
   to restrict and authorize any user transaction to
   the appropriate access level. This must include a
   sign-on procedure with operator identification (for
   labor statistic tracking). Password protection
   must be included in the access system.

o The completion of all exception or abnormal
   condition transaction should be simple, single
   key input whenever possible, with verification
   required prior to completing the transaction.

5.3.4   The programming language to be used for system
         application software may be determined by the system
         supplier, but Honeywell reserves the option to approve
         or disapprove the selection. Preferred languages are
         Pascal, C, or other widely used high level block
         structured languages. A proven, commercially
         available database system is a requirement. All
         programs must include adequate documentation to
         allow Honeywell personnel to maintain and modify
         them after "skill transfer" training sessions, which
         must be included as part of the training and acceptance
         procedures.

5.3.5   As a minimum, the security level access control for the
         MHS System should be as follows:

         A. All users must log on and off for each session
             with employee I.D. and user password (provided by
             the System Manager), which will identify the
             users security and access level, and functional
             access to MHS programs. A system log will be
             kept of each user session; log-on and log-off
             will be time stamped in the log. The security
             access should be hierarchical - a user can access
             functions from his/her level or below, but not
             higher levels.

         B. There will be four levels of security access:

Level 0: MHS System Manager - the highest and most restricted access level; system start-up and shut-down, password assignment, maintenance, etc.; unlimited access to all files and programs.

Level 1: Department Supervisor (Storeroom or Inspection) - the highest functional access to MHS application programs; review and modify files and activity lists; initiate reports and inquiries; examine operator activity data; access only to assigned department files and programs.

Level 2: Unassigned - reserved for future use.

Level 3: Workstation Operator Level- lowest level access to MHS application programs; allows only workstation operation transactions (CRT conversations) by station type (e.g., Receipts, Picking, etc.); once operator has logged on, a station type operation menu is displayed and drives the remainder of the session; all responses are validated, range checked, etc. Note: the workstation terminals should be restricted to only Level 3 access.

5.3.6   This order requirements and pick list generation is done by the HMS/CPL module, which runs on the Honeywell DPS-8 host computer. This module is run once a night, and generates order picking requirements for all orders that have been released by other HMS modules. This file is segregated into multiple Pick Lists, each with about 25 Orders. Each Pick List is sorted by Order number (equivalent to a kit list), and each Order number contains the exploded bill of material line items to be picked. Each line item on the Pick List contains all the information necessary to pick the part, including the Lot number (selected by HMS/CPL on a FIFO basis). Throughout the day, the stockroom supervisor will direct one or more of these Pick Lists to be downloaded to the MHS system, via access to a HMS terminal. All this activity is performed separately and independent from MHS.

The Pick Lists downloaded will also contain a number of information fields for each line item, which is printed on the Pick Ticket by MHS for future use in the assembly area. Once printed, these fields can be discarded. Hot Orders and Hot Picks are also downloaded to MHS in the same fashion. Normally, the Pick Lists that are downloaded to MHS will be batched together prior to picking for operator efficiency.

Each pick, store, count, and receipt transaction that is completed by MHS requires a specific completion record to be transmitted back to the HMS/CPL. This feedback process should be able to transmit the completion records in real time or to a journal file (if the link is not available). This journal file, since it will be in HMS specific format, will probably be separate from the MHS database journal file - which is used only to back up the MHS permanent data files. The details are included below.

All communications between MHS and HMS are performed on a real-time interactive basis as each activity(pick, etc.) is completed. Exact transmission protocol details are not available yet, but can be expected to be a high speed asynchronous serial communication link. MHS should also be able to receive from and transmit to a standard 9 track Magtape as an alternative to the HMS communications link.

5.4 Database Requirements

5.4.1   The preliminary system database requirements for transaction records to be downloaded from the HMS Business computer to the MHS system are defined as follows:

EXPECTED RECEIPTS TRANSACTION	CHARACTERS
PART NUM	20 A/N
LOT NUM (=inship num)	6 A/N
SUB-LOT NUM	6 A/N
QUANTITY (dock count)	7 N
DATE RECEIVED	6 A/N
WAREHOUSE	4 A/N

INSPECTION STATUS	2 A/N
ACCESS CODE (auth. level)	1 A/N
SHELF LIFE EXPIRATION	6 A/N
TO-STOCK-DATE	6 A/N
WAIVER NUM	6 A/N

PICK ORDER TRANSACTION

612F - Order Sequence Picks
613F - Location Sequence Picks
614F - Hot Picks

ORDER NUMBER	X(8)	*
REQUISITION ITEM	9(3)	*
WAREHOUSE	X(4)	*
LOT NUMBER	X(8)	*
DATE INSPECTED	9(6)	*
PART NUMBER	X(20)	*
QUANTITY	9(7)	*
ORDER MOVE-TO	X(8)	
DUE DATE TO FLOOR	9(6)	
OPERATION USED-IN	X(4)	
WORK CENTER OF OP	X(8)	
DESCRIPTION	X(20)	
PART REVISION.	X(2)	
PART MODIFICATION	X(2)	
DRAWING REVISION	X(2)	
DRAWING MODIFICATION	X(2)	
ADMIN CENTER	X(6)	
UNIT OF MEASURE	X(3)	
EMPLOYEE I/D	X(10)	
PROTECT CODE AND DESCRIPTION	X(22)	
HANDLE CODE AND DESCRIPTION	X(22)	
CONFIGURATION CODE AND DESCRIPTION	X(22)	
ASSEMBLY MATERIAL ITEM	X(20)	
ISSUE NUMBER	X(4)	
REFERENCE NUMBER	X(20)	
WAIVER NUMBER	X(4)	
LEAD FORM	X(5)	
TRACE CODE	X	

NOTE: Those fields marked with an asterisk (*) are
required for feedback to CPL. The other fields will be
required for printing Pick Tickets.

5.4.2   The frequency of downloading this information   to MHS
from HMS has not yet been determined,   but the MHS
system   should   be capable   of   handling   the
transactions on a frequent "demand", or asynchronous,
basis with transmission intervals on the order of
minutes rather than hours.   In this type of on-line
communications the data   to be passed between the two
systems would be queued   in "transmission   files" on
each system,   transmitted on   demand or request,   and
received into   similar transmission files.   Background
processing programs on each   system   would   monitor the
transmission files and control the data transmission and
management functions.   The system supplier must describe
the communication techniques proposed, and use this
design information   in sizing the file record lengths
for the system.

5.4.3   There are a number of files that will be permanently
resident on the MHS system,   including the   Part
master and IPI folder master record files.   Not all
these specific files   have   been determined, since the
exact file structure will be dependent   on   the final
detailed   system   design.   However,   the   following
basic Part and IPI master record   files are provided
since HMS   will   assume this information is resident on
MHS:

PART MASTER RECORD	CHARACTERS
PART NUM	20 A/N
LOT NUM (=inship num)	6 A/N
SUB-LOT NUM	6 A/N
QUANTITY - TOTAL	7 N
LOCATION - PRIMARY	6 A/N
LOCATION QUANTITY	7 A/N
DATE RECEIVED	6 A/N
WAREHOUSE	4 A/N
INSPECTIUN STATUS	2 A/N
DATE INSPECTED	6 A/N
ACCESS CODE (auth. level)	1 A/N
TO-STOCK-DATE	6 A/N
LAST CYCLE COUNT DATE	6 A/N
LAST CYCLE COUNT VARIANCE	7 A/N
LAST PICK DATE	6 A/N

IPI FILE RECORD	
FOLDER NUMBER	20 A/N
REVISION NUMBER	4 A/N
LOCATION	8 A/N
CHECK-OUT STATUS	2 A/N
LAST CHECK-OUT DATE	6 A/N
PROTECT CODE TEXT	20 A/N
CONFIGURATION CODE TEXT	20 A/N
HANDLING CODE TEXT	20 A/N

5.4.4   The approximate file size requirements in number of
         records for the files detailed above are as follows:

Part Master	80,000	Records
IPI File Master	25,000	Records
Expected Receipts	500	Records/day
Pick Order Requests	5,000	Records/day
Hot Pick Requests	500	Records/day
Cycle Count Requests	500	Records/day

5.4.5   Information to feedbackto HMS/CPL from MHS will normally
         be transmitted on a real time basis as each transaction
         is completed.   If the communication link is not
         available, these transactions will be journaled to a
         Magtape instead, for later transfer to HMS.   The MHS
         activities that generate HMS feedback transactions are
         detailed as follows:

         Stocking Transaction: Upon completion of each STocking
         transaction (see section 5.7), a 628A feedback record
         will be generated and transmitted to HMS/CPL.

         Picking Transaction: Upon completion of each line item
         pick or hot pick, a 612F or 614F (respectively) feedback
         record will be generated and transmitted.   The
         information for these records is those items marked by
         an asterisk (*) in the Pick Order transaction database.

         Unplanned Withdrawal: Any picks that are not generated
         by the HMS/CPL Pick List or Hot Pick transactions are
         designated an Unplanned Withdrawal.   These will be
         entered via a keyboard transaction directly to MHS, and
         upon completion require a 615F feedback record to be
         generated and sent to HMS.   The Reason Code and WIP
         Account Number are accounting information for HMS only,
         and will be supplied by the supervisor for entry during
         this transaction.   If the Unplanned Withdrawal is the
         result of removing a stocked item strictly for
         accounting purposes, a specific HMS feedback transaction
         call a 620F PO Feedback Reversal is required to send to
         HMS.   Note: This transaction is not yet completely
         defined, and can be ignored at this time.

         Unplanned Receipt: Similarly, it is possible to receive
         material that has not In-Ship record (see section
         5.7.11).   This material will require keyboard data entry
         of required information to MHS to stock the material.
         Items stocked in this manner require a 616F feedback
         transaction to HMS/CPL.

Location Transfer: Material that is "moved" from one
warehouse code to another (actually reclassified) in a
MHS local (manual) transaction requires a 617F feedback
transaction to update the HMS data base.

Stock Adjustment: If an adjustment is made to the
quantity of an MHS part via a local (MHS) transaction
for any reason, a 618F feedback transaction record is
required by HMS/CPL. The Adjustment Option and Reason
Code are accounting codes that will be supplied by the
supervisor.

Stocking of Completed Assembly: (see section 5.7.11)
One type of item that may be stocked into MHS via a
manual (i.e., not HMS generated) transaction is a
completed assembly. This requires a specific feedback
transaction to HMS - a 619F Supply Order Feedback.

The database requirements for these transactions are listed
as follows:

628A - Add Stock Acceptance Data

ORDER NUMBER	X(8)
REQUISITION ITEM	9(3)
LOT NUMBER	X(8)
DATE INSPECTED	9(6)
MATERIAL ITEM NUMBER	X(20)
WAREHOUSE	X(4)
QUANTITY ACCEPTED	9(7)
QUANTITY REJECTED	9(7)
WAIVER NUMBER	X(4)

615F - Unplanned Withdrawal
(not associated with current production)

MATERIAL ITEM NUMBER	X(20)
ORDER NUMBER	X(8)
REQUISITION ITEM	9(3)
WAREHOUSE	X(4)
LOT NUMBER	X(8)
DATE INSPECTED	9(6)
QUANTITY	9(7)
REASON CODE	X(2)
WIP ACCOUNT NUMBER	X(20)

616F - Unplanned Receipt

```
MATERIAL ITEM NUMBER         X(20)
ORDER NUMBER                 X(8)
REQUISITION ITEM             9(3)
WAREHOUSE                    X(4)
LOT NUMBER                   X(8)
DATE INSPECTED/REINSPECTED   9(6)
QUANTITY                     9(7)
REASON CODE                  X(2)
WIP ACCOUNT NUMBER           X(20)
WAIVER NUMBER                X(4)
```

617F - Location Transfer

```
MATERIAL ITEM NUMBER         X(20)
WAREHOUSE FROM               X(4)
WAREHOUSE TO                 X(4)
LOT NUMBER                   X(8)
DATE INSPECTED               9(6)
QUANTITY                     9(7)
REASON CODE                  X(2)
```

618F - Stock Adjustment

```
MATERIAL ITEM NUMBER         X(20)
WAREHOUSE                    X(4)
LOT NUMBER                   X(8)
DATE INSPECTED               9(6)
QUANTITY                     9(7)
ADJUSTMENT OPTION            X
REASON CODE                  X(2)
```

619F - Supply Order Feedback

```
ORDER NUMBER                 X(8)
REQUISITION ITEM             9(3)
ACTION CODE                  X
QUANTITY RECEIVED            9(7)
QUANTITY SCRAPPED            9(7)
LOT NUMBER                   X(8)
DATE INSPECTED               9(6)
MATERIAL ITEM NUMBER         X(20)
WAREHOUSE                    X(4)
EMPLOYEE I/D                 X(10)
WAIVER NUMBER                X(4)
REASON CODE                  X(2)
```

620F - PO Feedback Reversal

ORDER NUMBER	X(8)
REQUISITION ITEM	9(3)
ORDER STATUS	X
QUANTITY RECEIVED REDUCTION	9(7)
QUANTITY SCRAPPED REDUCTION	9(7)
WAREHOUSE	X(4)
MATERIAL ITEM NUMBER	X(20)
LOT NUMBER	X(8)
DATE INSPECTED	9(6)

5.5   Operating Description - Receiving

5.5.1   When material is initially received at the Receiving
               Dock, it is identified and verified via an on-line
               transaction to the Honeywell HMS business system
               known as in-shipping. During this process, a high or
               medium density code 39 (3 of 9) bar code label is
               printed and affixed to the original packing carton
               of the material with the following bar-coded
               information:

               o   Part Number
               o   In-ship (or Lot) number

5.5.2   A data record in HMS is also generated for the
               incoming material (see sec. 5.4), and downloaded to
               the MHS in the Expected Receipts file, keyed to the
               In-ship number. All material received via MHS will
               generate an In-Ship data record for MHS -material
               cannot be Receipted by MHS without this file available.

5.5.3   Upon completion of the receiving dock operation, the
               operator will place the labeled material in a tote
               (along with other received material) or on a cart,
               for manual transfer to the MHS Receiving Put-away
               station. If the material is too large for storage in
               MHS totes, it will be manually transferred directly
               to the MHS Bulk storage areas.

5.5.4   Received material will be manually transported from
               the receiving dock area to the MHS Receiving Station
               area. This station is where all material is first
               identified to the MHS system.

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5.5.5   The MHS Receiving Station operator will initiate a new
            Receipt transaction via the CRT terminal at the
            station. The in-ship bar code label will be scanned
            by the operator to identify the material to MHS. At
            this time the Expected Receipts file record for this
            material must be available to MHS or the transaction
            cannot complete and the material will be rejected.

5.5.6   If the In-Ship file shows that the material requires
            inspection, it will first be temporarily stored in the
            MHS carousel AS/RS until inspection. Processing for
            these items continues at section 5.5.9 below.

5.5,7   Material that requires no inspection is placed in a
            separate stores tote for routing directly to a
            Stocking station (step 6 in Diagram 2.1) via the
            conveyor system.

5.5.8   When this tote is filled, it is placed in the
            outbound conveyor position, the operator instructs MHS
            via the CRT that the tote is destined directly to a
            Stocking station, wands the bar code I.D. on the
            tote, and the tote is automatically conveyed to a
            Stocking station or temporarily queued in the Carousel
            AS/RS for the stocking operation (see Sec. 5.7).

5.5.9   Material that requires inspection will be processed
            as follows. The operator enters a packaging
            designation, specifying the approximate cube of
            the package. MHS will select a tote with available
            space and route this tote to the Receipts Station.
            At this point, the material sub-identifier WAREHOUSE
            type is first used. WAREHOUSE type is a logical
            inventory designation used by Honeywell to define a
            class of inventory or material that can be stored
            together - physically located in the same tote
            container. Parts that have the same part number,
            but different Lot numbers, will generally have the
            same WAREHOUSE designation, unless their inspection
            status is different, or if they are reserved for
            specific different programs. Note: parts or
            material of different WAREHOUSE desig-nations cannot be
            stored in the same tote and must be stored separately.

5.5.10   When the selected tote arrives, the Receipts
           operator scans the tote I.D. (a permanently
           affixed, unique bar code label on the outside of the
           tote), and the material bar code label, then places
           the material in the tote. If no other receipts are
           to be stored in this tote, it is moved to the
           station outbound conveyor position, the tote bar
           code is scanned, a transaction complete bar code
           is scanned, and it is then automatically conveyed to
           the carousel AS/RS. The material is now stored in
           the Carousel AS/RS system, in its original packing
           carton, awaiting inspection. It will be unavailable
           to anyone other than the inspection dispatch
           operator at this time.

5.5.11   Material destined for bulk storage is manually
           transported to a selected bulk storage location where
           a similar Receipts transaction is performed by an
           operator at a "remote" MHS station in that area. Bulk
           storage items will have the In-Ship bar coded label
           affixed directly to the material in most cases.

           Bulk Storage material is not replenishment material for
           carousel storage - it is large or bulky material that is
           not suitable for carousel storage.

5.5.12   When any Receiving transaction is completed, MHS
           automatically generates a journal file entry for the
           transaction, as it will for any transaction affecting
           the database. This journal file is available for
           upload to the HMS system on demand, or on a periodic
           basis.

           The HMS journal file record created will be immediately
           transmitted to HMS (or written to the HMS journal tape
           if the link is not available). This procedure will be
           the same for all feedback transactions.

5.6 Operating Description - Inspection

5.6.1   The Inspection process is driven by the CRP module in
           Honeywell's HMS business system. This module creates
           an Inspection Request File containing a record for
           each Lot of material to be routed to the inspection
           area, and a priority or due date for each one. This
           file is downloaded to MHS on a periodic basis.

5.6.2   The Inspection Dispatcher has a MHS CRT at the dispatcher's station. Upon request, the Inspection Request File is displayed, in due date order. The dispatcher can then indicate which items, or Lots of material, are to be scheduled for inspection, and which Inspection workstation to send them to. Minimal key entry should be required, using "cursor position / enter" type transactions.

5.6.3   Items scheduled for inspection are routed in priority sequence by due date to the Inspection Dispatch Station (where the Dispatcher resides) as space in the inbound tote queue at that station allows. This is to be an automatic process, as with all manned and active MHS stations. When there is room in the inbound tote queue, available work will always be sent.

5.6.4   When a tote arrives at the head of the queue at the Inspection Dispatch Station, the operator there wands the tote I.D. MHS then instructs the operator which item to remove from the stores tote, requiring a bar code scan of the in-ship label to verify the correct item.

5.6.5   The operator then places the item to be inspected in an empty tote.

5.6.6   During this time, the IPI folder vertical carousel must be automatically rotated to the correct shelf level, and a light illuminated above the correct bin to pick the matching Inspection folder. The operator removes the folder and wands the bar code label for verification by MHS of a match. The IPI folder identification number will usually be the same as the Part number of the material to be inspected. In cases where the Part number does not match the IPI folder number, a manual cross-reference listing will be used by the Dispatcher (not part of the MHS system) and the matching IPI number entered by keyboard. The IPI data file is kept by MHS.

5.6.7   The dispatch operator will request a list of all Inspection workstations that are signaling for work. At this time, the dispatch operator will assign the tote to a destination workstation. The dispatcher then places the IPI folder in the tote with the item to be inspected, wands a transaction complete lael at the

terminal, and the tote is automatically conveyed to the destination inspection workstation.

5.6.8   The inspection dispatch station terminal can also be used to query MHS as to the location of any IPI folder: checked in and stored at location number; or checked out to station number. Note that in some cases a folder will be "permanently" checked out to a specific station, A manual (key entry) check-out and check-in capability shall also be provided at this terminal to provide all necessary transactions to support the query and check-out functions, both by bar code label entry and keyboard entry.

5.6.9   During the time that the material is out for inspection, MHS does not track or control the items, other than to note which inspection station the item was sent to. The material can be in the inspection process for up to several days. When the inspection operation is completed, the inspection station operator simply returns the item in a tote to the Inspection Dispatch Station (conveyed automatically from the station outbound position), with the inspection results noted on the accompanying traveler document.

5.6.10 When the returned tote reaches the head of the inbound queue at the Inspection Dispatch Station, the dispatcher initiates a return or check in transaction, and wands the tote I.D. The IPI folder is removed and returned to storage in the vertical carousel via a check-in transaction which will automatically position the vertical carousel and direct the operator which location to store the folder.

5.6.11 The MHS database record for the material is updated by the inspection dispatcher in a terminal transaction next, indicating the new inspection status: inspected and Certified; inspected and Rejected; or still requiring inspection.

5.6.12 If the item passed inspection and is Certified, it is placed in a separate tote and manually stored in a flow rack adjacent to a Stocking station, where it waits for an available operator to initiate a Stocking transaction.

5.6.13 If the item did not pass inspection, it is returned to the MHS AS/RS via an inspection return transaction. An empty tote or one with other Non-Conformance status material in it is sent to the

station. The bar code I.D. of the arriving tote is
scanned, the rejected material label is scanned,
and the item is placed into the tote. A transaction
complete label is scanned, and the tote is
automatically returned to storage. It is now
restricted, and can only be retrieved by a
transaction with the inspection dispatcher's security
level code.

5.6.14   It is possible that material Lots returned from the
          inspection process can be divided into a portion
          that passed (Certified), and the remainder not passed
          (Non-Conformance). A "Lot split" transaction at the
          dispatcher station is required to allow the original
          material Lot to be split into two "sub-Lots", each
          with a different sub-Lot number. This operation can
          only be performed by the inspection dispatcher, at
          the time the material is returned from inspection.
          The material is returned from the inspection divided
          into two groups. Each sub-Lot is then treated as an
          individual material Lot, and returned separately via
          the appropriate transaction, as described above.

          This will effectively create a new Lot, using the sublot
          identifier. The sublot number will have been previously
          assigned by HMS. The other data fields will be the same
          as those in the original MHS In-Ship data record for the
          material, except the inspection status will be
          different.

5.6.15   The inspection dispatcher can at any time request a list
          be displayed of all material in MHS that is Rejected
          (Non-Conformance) and request that any of these items be
          issued to the dispatcher station. This transaction
          cannot be performed at any terminal other than the
          dispatcher station terminal.

5.6.16   Upon the completion of any inspection dispatch or return
          transaction, MHS generates a journal file record for
          uploading to HMS.

5.7 Operating Description - Storage Functions

5.7.1   Material for permanent storage in the MHS system
          arrives at a Stocking station (or is manually
          transferred from the adjacent flow rack) after
          completing the inspection process and being
          Certified. At this time a complete database record
          for the material exists except the final two items
          to be entered during the Stocking transaction - a
          final part count, and storage location.

5.7.2   The operator at the Stocking station initiates a
         Stocking transaction and then scans the bar code label
         on the packing carton.   The database record is then
         displayed on the terminal.

5.7.3   The operator then unpacks, detrashes, counts, and bags
         the parts. The count is entered via the keyboard.

5.7.4   A bar coded inventory label is then printed at the
         station and affixed to the bag. The label will
         include alphanumeric and bar coded data for the part
         number, Lot number, WAREHOUSE, and count.

5.7.5   The MHS system must calculate the storage space
         required by the new parts in order to select an
         appropriate storage location to maximize the
         density. This could be assisted by the operator
         entering a basic size / shape designator, to guide the
         MHS in selecting a tote with the same WAREHOUSE
         inventory designation and an empty sub-cell of
         appropriate size. In instances where multiple new part
         numbers are being stocked, it will be more
         efficient for the MHS system to direct the storage
         to the various sub-cells of a single storage tote at
         the Stocking station.

5.7.6   When selecting a storage location (tote and
         sub-cell), the algorithm to be used is:
         o   First select totes with the same WAREHOUSE type
             designation;
         o   If found, then look for the same PART number in a
             tote with available space of the correct size;
         o   If not found, then look for available space in
             a tote with the same WAREHOUSE type only;
         o   If not found, then select a new (empty) tote
             and assign it to the WAREHOUSE type of the new
             part;

         The storage hierarchy used therefore is: WAREHOUSE type,
         PART number, LOCATION.

5.7.7   Parts with the WAREHOUSE type designation for automatic
         insertion will always be stored in carousel number 6 as
         long as space is available. If carousel 6 is full or
         unavailable, the system will notify the operator and
         request an alternate storage location selection. The
         system will not store non-AI material in carousel 6
         unless all of the other carousels are full or
         unavailable.

5.7.8   Other than the requirement to not mix WAREHOUSE type
            designations in the same tote and the special
            requirements for carousel 6, parts are stored in
            random locations in the carousels. Locations should
            be assigned such that the loading across all carousels
            is balanced.

5.7.9   The stocking operator(s) shall have the capability to
            override the system, and manually designate a
            specific storage location or tote number for a part
            being stocked.

5.7.10   There will be two "remote location" stations, in the
            bulk areas, capable of performing all transactions,
            including Stocking. Transactions at these stations will
            be similar to those described above, without the
            automatic delivery and location selection.

5.7.11   An optional capability must be supplied in the
            software to allow one (or more) complete carousels to be
            dedicated to a specific WAREHOUSE designation (or
            designations), for cases where physical segregation
            of material is required.

5.7.12   Step 11 on Diagram 2.1 shows Material Transfers to the
            MHS system - a Stocking function separate from the one
            at step 6. This transaction allows material that
            has no In-Ship data record available from HMS to be
            stocked into the MHS system. Material that would
            normally be stocked via this transaction includes
            source inspected material, subassemblies being
            returned from the factory (FAB/FAC material),
            material transfers from other Honeywell warehouses,
            etc. These items will be transferred by manual
            means directly to a MHS station designated as a
            Restock station. Manual keyboard entry will be
            required to build a minimal MHS database record for
            these items, that will include: Job num., Part num.,
            Lot num., WAREHOUSE, quantity, and inspection status.
            Material arriving for Restock can be of any
            inspection status - Certified, not yet inspected,
            or not requiring inspection.

            Items arriving for stocking via this manual data entry
            step will require specific completion or feedback
            transactions to be generated and sent to HMS to update
            the master data base, depending on whether the item is a
            part or completed assembly.

5.7.13   Upon   completion   of any Stocking   transaction,   a
                journal file record is generated and added to the file
                to be uploaded to HMS. This journal record will be
                transmitted to HMS as soon as the transaction is
                completed.   If the link is not available, the record
                will be written to a Magtape file.

5.7.14   Exception condition processing transactions   must be
                included for a variety of conditions, including a
                decision   to cancel (not complete the   stocking
                operation), restart the transaction, etc.

5.8 Operating Description - Order Picking

5.8.1   Order picking is   initiated   at   the   Storeroom
                Supervisor Station. A MHS terminal located there will
                allow the supervisor to request a list of all pending
                Orders, from   the   Pick List(s) downloaded from HMS.
                This display will show the Order   numbers   sorted by
                "need date"   order.   An Order generated by HMS is a
                complete pick list for a kit or subassembly, and will
                contain   multiple line   items, each   including   the
                PART   number, lot number, WAREHOUSE   type, and
                quantity required.

5.8.2   Orders   are   downloaded   in batches   from HMS   at
                random intervals. Upon receipt and verification, they
                are added to the Requirements List file in MHS.

5.8.3   The Storeroom supervisor has the capability to mark
                and   release for picking any of   the   Orders being
                displayed, via a simple   cursor   position   type
                transaction.   These can   be   released either
                individually,   or in designated batches for batch
                picking. Batch picking would be the normal case.   The
                supervisor   will also have to   capability   to suspend
                or   cancel   an Order or   batch   group   of Orders that
                have already been released for picking.

5.8.4   The Storeroom Supervisor Station terminal will also
                provide the capability to perform   a   stock quantity
                analysis on one or more pending   Orders, either
                individually or in batches. This capability will   search
                the MHS part database and   report   if sufficient
                quantities of all the required PART number/WAREHOUSE
                numbers called   for   on   the Order(s) selected   for
                analysis are currently available, and if not, how
                many kits can be filled.

5.8.5   FIFO sequence must be maintained when picking MHS parts. The HMS/CPL program will select the oldest Lot for a given Part Number and Warehouse Number, and include this with the Pick List line item. If there are insufficient parts to fill the order from this Lot, MHS will select another lot number of this Part (and Warehouse) on FIFO basis to fill the Order. Note that parts picked in this manner from a different Lot number must be separately bagged and labeled for future traceability.

5.8.6   As each Order is released for picking, it is removed from the Requirements List file and scheduled for picking. The system shall attempt to optimize the utilization of all workstations currently designated as Picking Stations, for maximum operator productivity. Thus, an individual Order may actually have line items picked at several workstations, and each operator will pick parts for multiple Orders. The items will be consolidated at the Sortation Station, described below. Batch picking of multiple Order numbers will increase the overall productivity and reduce the number of tote retrievals required during a shift.

The capability must also be provided to designate specific orders for complete order picking at a given work station. In this case the order will not be batch picked and all parts for the order will be picked sequentially at one pick station until the order is complete. Orders for automatic insertion will typically be picked in this way at the AI picking station.

5.8.7   In order to minimize the carousel rotation times, when a designated Part Number/Lot Number to pick resides in more than one carousel location, that location closest to the head (or robot) should be selected.

5.8.8   Each workstation can be assigned one (or more) operation types by the supervisor at any time. The operation types are Receipts, Stocking, Picking, Cycle count, or Hot Pick.

5.8.9   When operators first arrive at their workstations, they are required to sign on and identify themselves by their employee I.D. numbers. Productivity data is then logged and maintained by the MHS system for each employee by shift, week, and month. This data is available only to the Storeroom Supervisor.

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5.8.10   After an operator has logged onto a Picking designated station, the MHS system will begin routing totes to that station. As each tote is moved from the head of the inbound queue to the work position, the operator initiates a pick transaction. The bar code label I.D. of the tote is scanned using the hand held scanner at the station. The terminal then displays which tote sub-cell contains the parts to pick. The operator removes these, and scans the label on the parts bag for verification. The terminal then displays the quantity to pick.

5.8.11   When the parts are counted and bagged in a separate bag, a bar code label is printed and attached to the bag. If there are other Orders to pick this part for, this procedure is repeated. Otherwise the original parts bag is returned to the tote sub-cell, and the picked and labeled part bag is placed in a separate tote which, when full, will be sent to the sortation area. This procedure will be repeated for other part numbers in other sub-cells in the tote, if required, until all batched pick requests for parts in this tote are satisfied.

5.8.12   Exception condition processing transactions must be included for possible abnormal conditions. If there are insufficient parts to pick the order complete, MHS should route another tote with the same part (possibly from a different Lot number) to the station and generate another transaction to complete the pick for that part. If no other locations contain this part, a "shortage" journal file entry must be created for uploading to HMS, and a Back Order record must be created and maintained by MHS. Later, when another pick request is processed on this part to fill the Back Order, a message should be displayed to alert the operator that this is a Back Order pick so it can be handled appropriately at the Consolidation area.

5.8.13   The tote is then moved to the outbound, or return conveyor position, a return transaction initiated, and the tote I.D. scanned. The tote is then automatically conveyed back for storage in the carousel AS/RS.

5.8.14   When the operator judges the sortation bound tote is
            full (of bagged, labeled parts), he initiates a
            "transfer to Consolidation" transaction via the CRT.
            The tote is moved to the outbound conveyor position,
            the tote bar code I.D. label scanned, and it is
            automatically conveyed to the inbound tote queue in
            the Sortation area. If the queue is full the tote may
            temporarily be stored in the Carousel AS/RS.

5.8.15   "Hot picks", or immediate picks, are performed in the
            same manner as described above, with the following
            exceptions. The operator will be notified on the
            CRT that the pick from the arriving stores tote
            is a Hot Pick. The pick transaction will be
            performed immediately. The parts counted, bagged,
            labeled, and placed into an empty tote along with a
            special color-coded Hot Pick marker card. Several hot
            picks may be placed in the tote before release. The
            stores totes will be returned after each pick and a
            "transfer to consolidation" transaction will be input
            prior to sending the tote to the consolidation area.

5.8.16   Upon completion of any picking transaction the
            appropriate HMS transaction image and journal entry
            will be generated. There are also three possible
            picking type transactions that would be initiated
            locally (i.e., not via a HMS request). These are an
            Unplanned Withdrawal (not the same as a Hot Pick), where
            a part is required by a person on the assembly floor for
            a variety of reasons; a Location transfer, where a Lot
            of parts is given a different Warehouse designation, for
            a variety of reasons; and a Stock Adjustment, where the
            count of a part Lot is adjusted. Each of these manual
            transactions requires MHS transaction conversations, and
            specific HMS feedback records.

5.9 Operating Description - Cycle Counts

5.9.1   Cycle count transactions are initiated either by a
            request downloaded from HMS or by the Stockroom
            Supervisor. They are scheduled for activity the same
            as Pick requests, and routed to an available station
            that is designated as a Cycle Count station
            currently.

5.9.2   When the tote arrives at the Cycle count station, the
            operator initiates a new transaction via the CRT
            terminal, and scans the tote bar coded I.D. label.
            The MHS instructs the operator to remove material from
            a particular sub-cell for the count. The operator then
            scans the bar coded label on the parts bag for
            verification.

5.9.3   The operator empties the bag and performs the
            count, entering the quantity via the CRT and again
            scanning the parts label for verification. The parts
            are then returned to their original location. If
            other cycle counts are scheduled for parts in this
            tote, this process is repeated. An appropriate HMS
            transaction image will be written to the journal.

5.9.4   When all cycle counts for parts in the tote at the work
            position are complete, the MHS CRT instructs the
            operator to return the tote. A return transaction
            is initiated, the tote moved to the return position,
            its I.D. label scanned, and it is automatically
            returned to the carousel AS/RS.

5.10 Operating Description - Material Consolidation

5.10.1   Since the individual line items in each Order are
            picked at various Pick stations at different
            times, they must be consolidated back into a
            complete Order. Material arrives at the Sortation area
            as individually bagged and labeled part numbers,
            in a tote to the inbound conveyor queue. Hot Pick and
            Back Order items also have a special color coded card
            in or on the tote to alert the sortation operators.

5.10.2   A sortation operator will remove the labeled part bags
            one at a time and scan them with the hand-held laser
            bar code reader.

5.10.3   If the part is the first line item in an Order to
            arrive at the Sortation area, the operator is
            instructed by the MHS CRT to place an empty
            sortation tote into a specific available (empty)
            matrix position, which will have an indicator light
            illuminated above it, and scan the bar code label on
            that position to verify. This matrix position will
            now be dedicated by MHS to this Order number until
            all line items previously picked for this Order
            number arrive to the sortation area, are scanned
            and sorted to the position.

5.10.4   As each part bag is removed and scanned, a light above
            the matrix position for that Order number is illuminated
            by MHS. Two colors of lights will be used to
            differentiate between items scanned by each of the
            two laser guns. The operators will place the part bag
            into the tote in the indicated matrix position, and push

the adjacent transaction complete button for that matrix position to verify that it has been placed in the proper tote. If the wrong button is pushed, the system must provide audible and visual indication of the error.

5.10.5   If the sorted part bag is the last line item in an Order (i.e., completes the Order), the operator is alerted through flashing indicator lights after the part is sorted to the matrix position, and instructed to push the tote back in the matrix for removal. The matrix position is now empty and released by MHS, and is now available for another Order number as needed.

5.10.6   When the last line item is sorted for each Order, a complete line item Order Pick List is printed on a printer in the sortation area by MHS. This listing will include: a complete database record for every part number/Lot number item in the order, and the quantity picked; a destination location (downloaded from HMS with the Order); and a "to be completed" remark for any unfilled line items from the bulk storage area or WAREHOUSEs not held by MHS (again, this infor-mation is downloaded with the Order by HMS).

5.10.7   The operator will be instructed to remove the Order Pick List listing after printing and place it with the matching Order number in the sortation tote.

5.10.8   Items not picked from MHS carousel AS/RS, but called for on the Order Pick List will be consolidated with the order manually from Bulk stores or from other Honeywell WAREHOUSEs.

5.11 Operating Description - Bulk Material

5.11.1   Bulk material is that which cannot fit into the storage totes. This includes sheet metal, lengths of pipe or bar stock, skids of supplies, containers of flammable liquids, etc.

5.11.2   When material arrives at the receiving dock, a decision is made by the operator during the receiving process to HMS that the material will be destined for MHS Bulk storage. An In-Ship label is printed and affixed to the material, the In-Ship data record created and downloaded to MHS, and the material transferred manually to the MHS Bulk storage area.

5.11.3   When the material arrives in the Bulk storage area, the operator there decides on an appropriate storage or rack location and stores the material. A Receipts transaction is initiated on the MHS CRT located in the area, similar to the other Reciepts transaction, except the operator informs the MHS system of the material location.

5.11.4   When material in Bulk storage is called for inspection, the inspection dispatcher will notify an appropriate inspector of the material identification and location. Once inspection is completed, the inspection dispatcher will be notified and will initiate an inspection return transaction for the material to update its inspection status, again with no actual movement or relocation of the material.

5.11.5   Bulk material line items called for on Pick Orders from HMS will be routed to the CRT in the Bulk area after the Order is released by the storeroom supervisor.

5.11.6   Released line items for picking will be displayed on the CRT in the Bulk area. The operator removes the required material manually, and completes the pick transaction by keyboard entry. A bar code part label is printed and affixed to the material. It is then manually transferred to the Order pick-up area, where it will be consolidated with the remainder of the Order when the Order Pick list is printed in the Sortation area.

5.12 Reports and Inquiries

5.12.1   In order to assist Honeywell management in effectively managing the MHS operations there must be a complete set of management and productivity reports, and similar on-line query capability. The specific format and content of these reports and queries have not been detailed, but the set of reports and queries must include as a minimum the following:

o   Bin Map: Complete list of the tote number in each carousel bin/shelf location.

o   Stock by Location: List of parts in specific range or series of locations.

o   Order Listing: List of all line item parts called out in a specific pick Order that is pending in MHS.

o   Operator Activity Report: Daily activity by operator I.d,, cumulative by week and by month, including log-on and log-off time, all transactions initiated and completed by type, and all errors logged during the session.

o   HMS Released Report: List of Order Pick request jobs that have been released by HMS to MHS since last report.

o   Part Location Report: Complete list of all part numbers, quantity, and lot - by location - in MHS WAREHOUSES.

o   Available Space Report: Summary of available space, by WAREHOUSE designation.

o   Pending Put-Aways: List of all parts in MHS waiting to be stocked.

o   Empty Location Report: Listing of all empty locations by WAREHOUSE designation.

o   Performance Measure: Operator summary of work performed against labor standards, and Departmental performance against established labor standards (samples to be furnished by Honeywell).

o   Complete error log per shift, including error identification, location, operator, and corrective action (if any).

5.12.2   The system must have the capability to support on-line query (CRT requests) for display of information regarding system status, backlogs, errors, and run-time performance. In addition, the system must have the capability to print the output from any query. Query capability must include as a minimum the following:

o   System status- showing the status (busy, idle, down or off-line, queue full, and any errors) of all system components and devices.

o   Work queues- summary of all transactions or requests queued for each station and device.

o   Location and status - of each part number, tote number, and storage location known to the system.

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o   Cycle count / verify - showing all cycle count
    and quantity verification   trans-actions (since
    last report), including the location, quantity
    counted, and any variance and correction.

o   Journal file display - display a window into the
    ourrent Journal file,   and move up or down
    through the file.

o   Shift performance - show summary measurements of
    performance factors maintained for the shift, by
    station or operator;   equipment activity
    statistics for   each   device since start of
    shift; and downtime statistics for each   device
    since the start of the shift. Also, maintain
    and show overall system performance   since the
    start of the shift, including total transaction
    completed by type.

5.13 System Performance

5.13.1   The MHS control system must maintain absolute control
         of record contents and validity,   and have fool-proof
         procedures for backing up and restoring all system files,
         and a clear hierarchy and identification scheme for
         backup material.

5.13.2   The MHS system must be able to support the stated average
         and peak throughput requirements of each of the material
         handling system components (see section 6).

5.13.3   The   MHS system must be able to perform all system
         functions with 95 percent of the terminal response times at
         less than 5 seconds during full operation at peak system
         throughput rates with all stations manned and active,
         while maintaining required response and throughput
         requirements for material handling system components.

5.14 system Redundancy / Backup

5.14.1   The MHS will be an essential part of the Honeywell
         Avionics operations. The control system must be designed
         to provide hardware and software reliability that will
         support the overall material handling and material
         management system requirements of 98 percent availability
         (up time).   In this requirement the system will be
         considered "down" or "un-available" when there is any
         equipment or software failure that affects the
         functionality of the system.

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5.14.2   The system supplier must indicate in his proposal whether control system hardware redundancy or special software features are required to meet the system availability requirements, and how he intends to meet and demonstrate the requirements. Any special system hardware or software requirements must be clearly stated and include separate pricing, and be shown as optional items for consideration.

5.14.3   The supplier must also indicate in his proposal the types of degraded system operation that are possible, the operating procedures, and the record keeping and database restoring procedures to be followed during the following failure conditions:

o   Operation without the HMS computer available.

o   Operation without the MHS system available.

o   Operation under various material handling system or equipment failure conditions, or partial availability.

5.15   Information Flow Diagrams

A graphical representation of the information flows that have been described in this section is included on the next few pages.
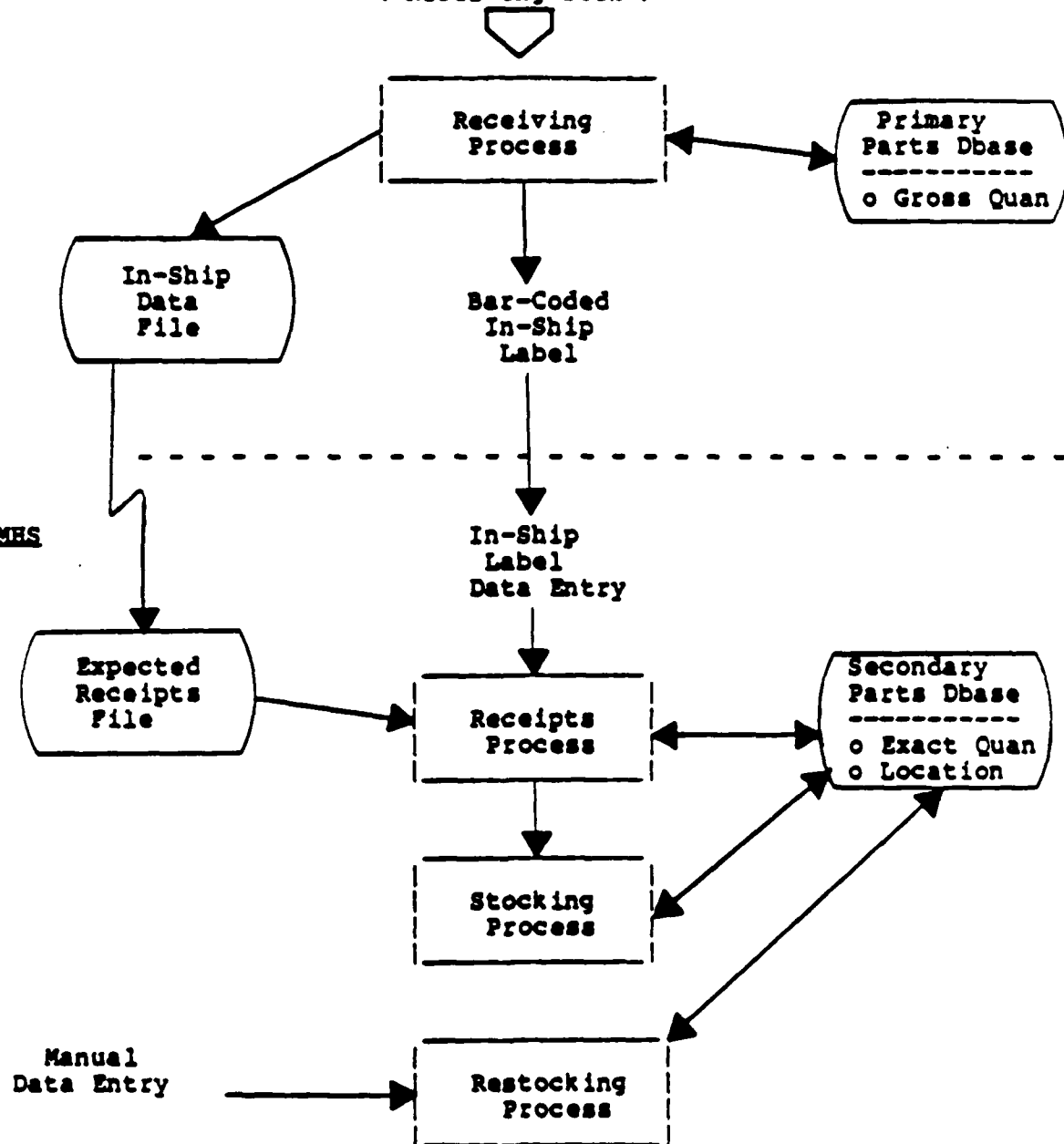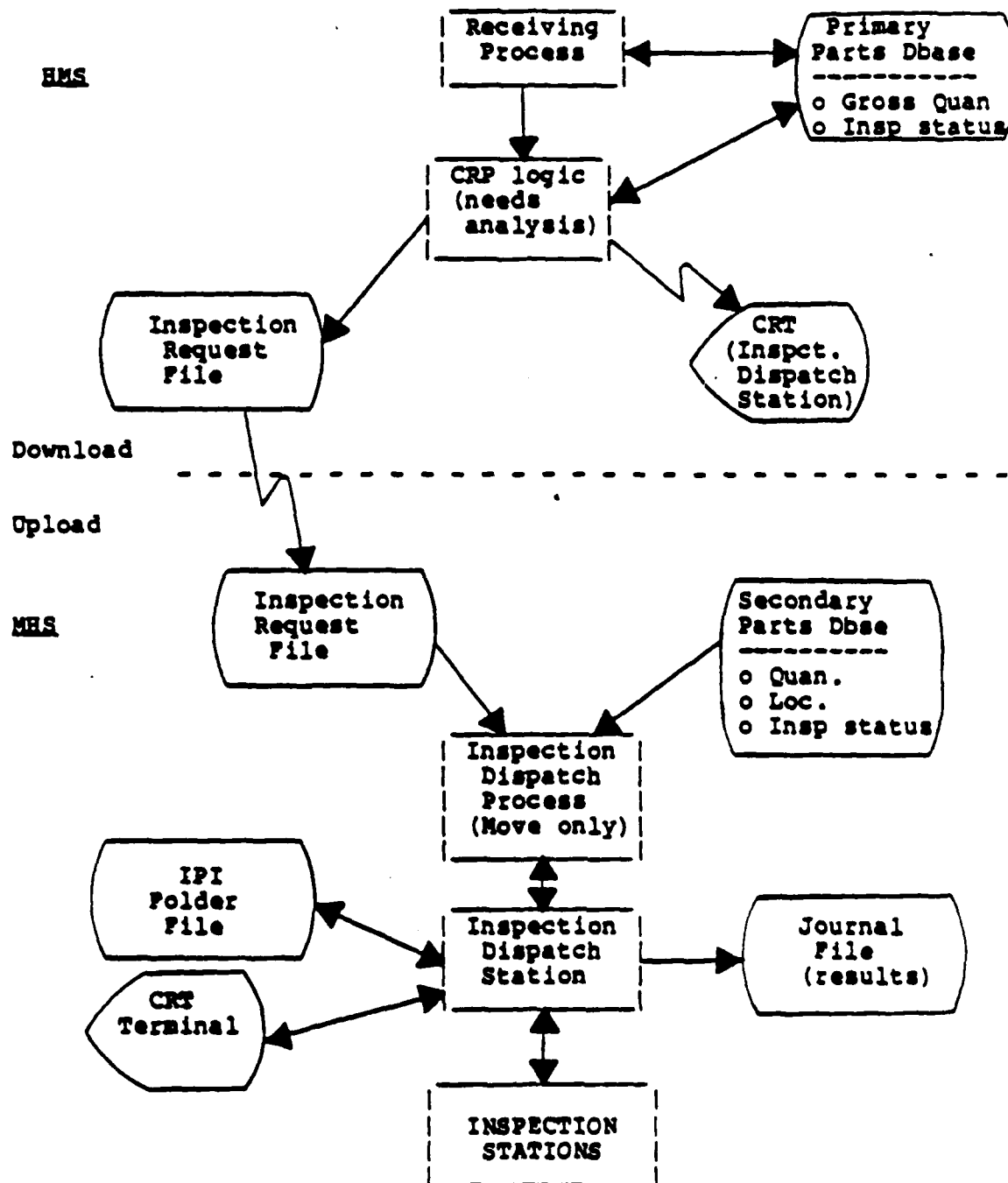
5.15.1   Receiving/Stocking Operations

HMS

```
                        < Receiving Dock >
                              \/

          ┌─────────────────┐          ┌──────────────┐
          │   Receiving     │◄────────►│  Primary     │
          │   Process       │          │  Parts Dbase │
          └─────────────────┘          │ ------------ │
            /           │              │ o Gross Quan │
           /            │              └──────────────┘
          ▼             ▼
    ┌──────────┐    Bar-Coded
    │ In-Ship  │    In-Ship
    │ Data     │    Label
    │ File     │
    └──────────┘
         │
         │ - - - - - - - - - - - - - - - - - - - - - - - - - - -
         │              │
         ▼              ▼
   MHS            In-Ship
                  Label
                  Data Entry
    ┌──────────┐       │
    │ Expected │       ▼
    │ Receipts │──►┌─────────────┐      ┌──────────────┐
    │ File     │   │  Receipts   │◄────►│  Secondary   │
    └──────────┘   │  Process    │      │  Parts Dbase │
                   └─────────────┘      │ ------------ │
                         │              │ o Exact Quan │
                         ▼              │ o Location   │
                   ┌─────────────┐      └──────────────┘
                   │  Stocking   │◄────►
                   │  Process    │
                   └─────────────┘
                                   
   Manual          ┌─────────────┐
   Data Entry ────►│  Restocking │◄───
                   │  Process    │
                   └─────────────┘
```
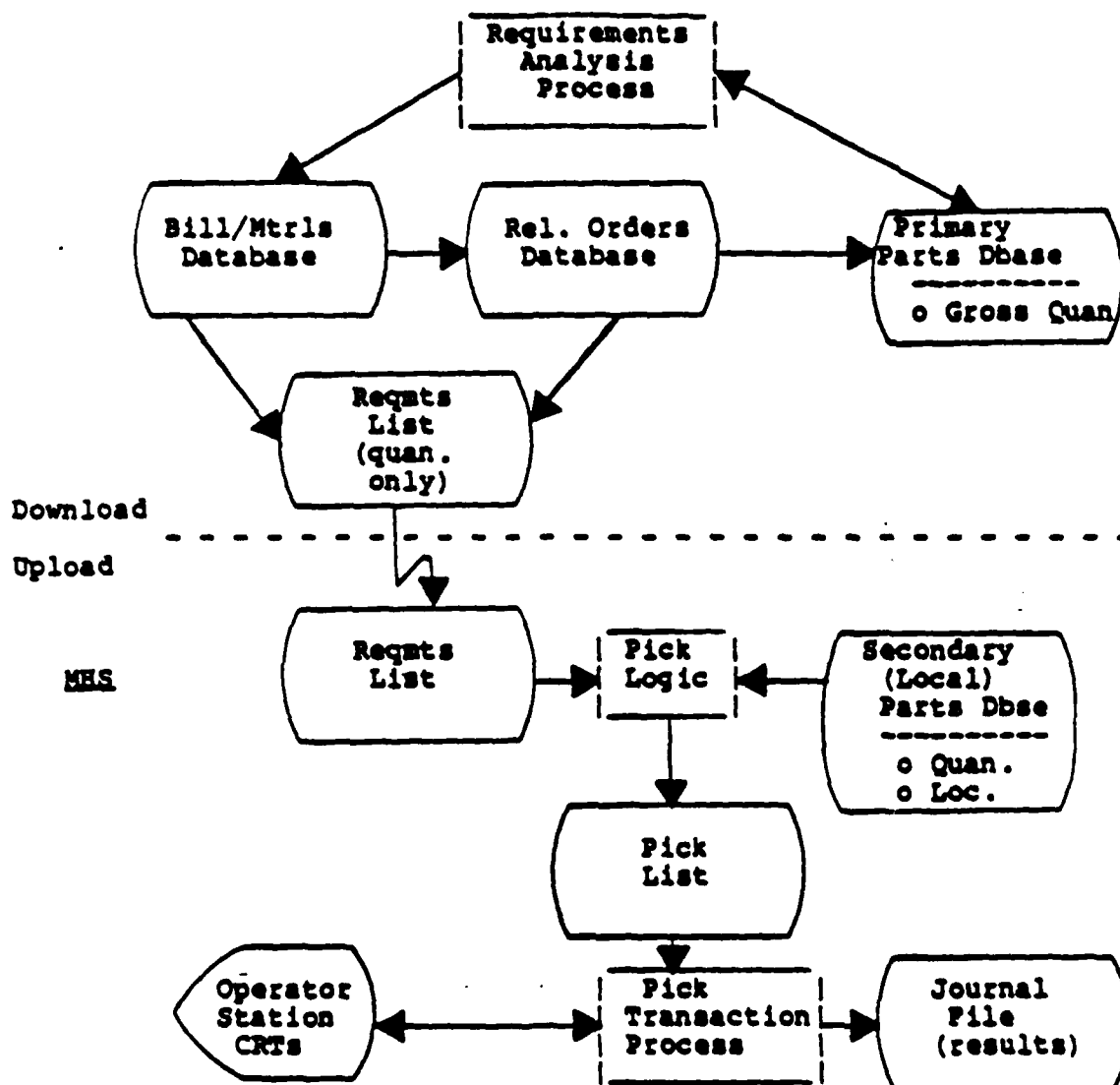
5.15.2   Inspection Operations

5.15.3   Stockroom Operations

SECTION 6.0

HONEYWELL MHS DESIGN PARAMETERS

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6.0 HONEYWELL MHS DESIGN PARAMETERS

6.1 General Requirements / Objectives

6.1.1   The new equipment and systems to be installed as part of the Honeywell Material Handling System automation project must meet the following general requirements:

   o Support Honeywell's stockroom and receiving inspection area modernization plan.
   o Make significant improvements in service levels, response times, and productivity in these areas.
   o Significantly increase order storage and picking accuracy while reducing personnel required.
   o Support oneywell's HMS business system operation and pr cures, while remaining a stand alone system capable of running independently for sustained periods.
   o Modernize the stockroom and inspection areas and operations with current or state of the art automated equipment and methods
   o Provide a completely automated parts handling and tracking system from receiving dock, through inspection, to stock, and through the kitting operation, in preparation to go to the production operations. The system should easily interface with an *automated production system* that will be procured at a later date.

6.2 Data Elements

6.2.1   In order to determine the exact requirements for the MHS Automation Project, a substantial operating requirements database was developed through a detailed study and design effort. This database includes the following types of data:

   o Current cubic volume requirements and utilization.
   o Current activity requirements by type.
   o Stockroom activity by WAREHOUSE type, and by function.
   o Picking activity requirements by zone, and by batch size.
   o HMS data processing requirements
   o Personnel headcount and classification.
   o Labor grades and costs.

o   Existing and expected physical building constraints and requirements.

o   Standard and measured dwell times for operators by activity type.

6.2.2   The database requirements were analyzed and projections of future requirements for the 1995 time frame were estimated. The future requirements were determined by taking into account the proposed addition and deletion of business units, changes in operating procedures, make versus buy decisions, just-in-time planning, future business growth projections, and other future projections. The resulting requirements are summarized in the following sections.

6.3 Storage Requirements

6.3.1   The carousel storage requirements have been determined through an analysis of the current storage volumes and net utilized space, the projections of future changes, and allowances for empty totes and empty locations in the carousels.

6.3.2   The storage requirements are based on estimated 1995 levels and methods of production. Sufficient space has been allocated for all the empty totes that could fit in work station queues to be stored in the carousels. Approximately ten percent of the carousel locations have been allocated as empty locations (with no empty totes or full totes) in order to allow enough locations for efficient system operation.

6.3.3   In the carousel tote storage, up to 24 separate items or unique part / lot numbers may be stored in sub-cell locations, depending on the size of the bagged parts.

6.4 Conveyance Requirements

6.4.1   The tote traffic in the system has been estimated through manual calculations of expected average tote activity. These requirements are summarized in Diagram 6.0, which shows estimated daily tote movements between the major storage areas and work stations. Note that the functions of the Empty Tote Conveyor Queue are not shown in this model, and all empty tote storage is considered to be performed in the carousel system.

ST. LOUIS PARK DAILY TOTE ACTIVITY

DIAGRAM 6.0

6.4.2   The major assumptions and calculations Involved In determining the tote movements shown In Diagram 6.0 are summarized as follows:

Receiving

1. Total Inships and stock returns = 450/day.
2. All Inships and stock returns require Inspection.
3. An average of 3 Inship/stock returns can be placed In a tote.
4. Tote activity = 450 @ 3/tote = 150 totes/day.

Inspection Dispatching

1. Total of Inships and stock returns/day to Inspection = 450.
2. Of the 450 totes brought out to Inspection Dispatch, 300 totes will be returned to stores (parts remaining) and 150 will be returned empty.
3. The 450 to be Inspected will be sent to Inspection work stations In Individual totes.
4. Once Inspection Is complete, the 450 totes will be returned to the dispatcher.
5. Of the 450, 90% = 405 will be accepted and sent to stocking off-line.
6. Of the 450, 10% = 45 will be rejected and returned to stores to await disposition.
7. On the average each day, 45 first pass rejects will be brought out to the Inspection dispatcher for disposition. Of these, 75% =34 will go off-line to be scrapped or returned to vendors.
8. Empty totes that return from the off-line queues (total of 450) will be used to supply the Inspection Dispatcher with totes for dispatching new work to Inspection.

Stocking

1. Items to be stocked Include 350 material transfers from off-line that do not require Inspection plus 439 accepted material totes from the Inspection Dispatcher, for a total of 789.
2. Of the Items to be stocked, 90% = 710 will be stocked? In new locations (empty totes) @ 12 part numbers/tote = 60 totes. Of the Items to be stocked, 10% = 79 will be stocked In existing parts totes @ 1 part number per tote = 79 totes.
3. The totes that came off-line from Inspection Dispatch (439) will be returned empty to the Inspection Dispatch area.

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Picking

1. The 3365 computer generated ticket picks will be batched and picked at an average of 3 picks/tote = 1122 totes required. These will be batched @ 25 picks/tote and sent to consolidation = 45 totes.
2. The parts totes from the picking operation will be returned with 1062 going to parts storage and 60 to empty tote storage.
3. The 1435 hot line picks will be picked @ 1 tote/transaction (= 1435 totes) and batched @ 3/sortation tote = 479 totes. All hot line pick totes are assumed to return to parts storage after picking.

6.5 Workstation Requirements

6.5.1   Input / output devices connected to the MHS system for operator use at the workstations shall include:

o Picking/Stocking Stations: (16 total)
   1 CRT terminal and keyboard
   1 Bar code reader (wand type)
   1 Bar code printer for every two stations
   (shared by two adjacent stations)

o Automatic Insertion Pick Station (1)
   1 CRT terminal and keyboard
   1 Bar code reorder (wand type)
   1 Bar code printer

o Receiving Stations: (2 total)
   1 CRT terminal and keyboard
   1 Bar code reader (wand type)
   1 Bar code printer

o Inspection Dispatch Stations (2 total)
   1 CRT terminal and keyboard
   1 Bar code reader (wand type)
   1 Report printer (shared by the two stations)
   1 Bar code printer (shared)

o Inspection Stations
   <No MHS I/O devices or communication>

o Bulk Area Stations (2 total)
   1 CRT terminal and keyboard
   1 Bar code reader (wand type)
   1 Report printer
   1 Bar code printer

     o Consolidation Stations (2 total)
       1 CRT terminal and keyboard
       1 Bar code reader (hand held gun type)
       1 Report printer (shared)
       1 Bar code printer (shared)

6.5.2   Input / output devices connected to the MHS system for the use of supervisors and managers in their offices shall include:

     o Stockroom Supervisor's Office (1 total)
       1 CRT terminal and keyboard
       1 Bar code reader (wand type)
       1 Bar code printer

     o Stockroom Manager's Office (1 total)
       1 CRT terminal and keyboard
       1 Bar code reader (wand type)

6.6 Activity Requirements

6.6.1   The daily system activity requirements must be met in a two shift work day. Each shift may be assumed to include 7.5 hours of productive operator time and 8 hours of equipment operation time.

6.6.2   On the average, when multiple orders are released for picking and batched together, each part number called out as a line item pick will be common to 3 Orders. Stated another way, each tote visit at a picking station will satisfy, on the average, 3 line item picks, for a "batching factor" of 3.

6.6.3   The MHS terminal response time must average under 3 seconds during normal or average activity loads on the system. During peak activity loads, 95% of all terminal response times must be less than 5 seconds. Average activity load is defined as all stations and functions active, processing trans-actions at a rate which would sum to the stated monthly, weekly, or daily average number of trans-actions when operating on two 7.5 hour shifts per 5 day week. Peak activity load is similarly defined, for the stated peak activity per period. This same response time requirement shall apply to all operator input / output devices at the work-stations, including printers, bar code printers, and bar code readers.

6.7 Building / Physical Requirements

6.7.1   System   layouts   have been shown In   the   building
                spaces   that   have been made avaIlable for   system
                InstallatIon.   Alternatives that use these   areas
                should   generally   comply wIth the   buIldIngs   and
                physical layout requIrements,

6.7.2   Changes In the buIldIng that are requIred In order to
                Implement   the system confIguratIon   as   shown wIll   be
                consIdered and Incorporated by   Honeywell wheneverthey
                are   practIcal   and   econoicaIly justIfIabIe.Changes
                In the buIldIng   that   are requIred   to   Implement
                alternatIve proposals   and layouts wIll   also be
                consIdered, but the requIrements for changes In the
                buIldIngs wIll be Included as posItIve or negatIve
                evaluatIon factors durIng the analysIs of the
                alternatIve.

6.7.3   If specIfIc facIlIty or utIlIty requIrements   are of
                concern durIng the preparatIon of   the   system proposal,
                Honeywell wIll attempt to obtaIn answers regardIng   the
                feasIbIlIty and costs InvoIved   In makIng the changes.

SECTION 7.0

GLOSSARY OF TERMS

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7.0 GLOSSARY OF TERMS

7.1 Glossary of Terms

The following Glossary of Terms lists some of terms that are used in this specification and may not be familiar to people other than the Honeywell Project Team:

AI - Automatic Insertion

AS/RS - Automated Storage and Retrieval System BOS - The

Honeywell Business Operating System
BULK MATERIAL STORAGE - The class of material that is too large to fit in the standard material handling totes.

DPS-6 - The Honeywell Departmental Minicomputer System hardware.

DPS-8 - The Honeywell Large Scale Mainframe Computer System hardware.

FAB/FAC - The Honeywell Fabrication Facility.

HMS - The Honeywell Manufacturing System, an MRP-type system.
HOT PICK - A high priority picking requirement that is usually not planned in advance.

IN-SHIP - The document or equivalent data record that defines a new receipt.

I/O - Input/Output conveyor or other device.

IPI - Inspection Procedure Information folder for use in Incoming Inspection.

MHS - The proposed Honeywell Avionics Division Automated Material Handling System control hardware and software.

SORTATION/CONSOLIDATION AREA - The area where batched picks are sorted into their individual order totes and consolidated with other picking requirements for the same orders.

TOTABLE MATERIAL - Material that will fit within the standard material handling tote dimensions and weight capacity requirements.

WAREHOUSE - A logical inventory designation used to define a class of inventory material that can be stored together and physically located in the same tote.

SECTION 8.0

LAYOUT DRAWING

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8.0 LAY OUT DRAWING

8.1 Layout Drawing

The system layout drawing is MHS-1 (Rev. A).

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